AIR QUALITY

NORTHWESTERN ONTARIO

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SUMMARY

This report presents results of the air quality assessment programme in northwestern Ontario for 1981. It includes data from nine communities in the region where long-term monitoring surveys were active during the year, plus summaries of special investigations in the Thunder Bay area.

ATIKOKAN

Concentrations of suspended particulate matter, measured at the Atikokan Weather Station, continued to be acceptable.

A snow sampling survey in the vicinity of a particle board plant revealed that emissions of particulate matter were causing a local nuisance problem. Abatement action is under way and follow-up sampling will be carried out.

To complement an air quality monitoring programme being undertaken by Ontario Hydro, the Ministry commenced a comprehensive vegetation and soil assessment study to obtain pre-operational information before the scheduled start-up date, in 1984, of a new lignite-fueled thermal generating station just north of Atikokan. This investigation, to be reported separately, is integrated with studies of acidic precipitation in Quetico Provincial Park and surrounding area.

BALMERTOWN

Vegetation sampling showed that moderately elevated arsenic levels persisted in an area on company property around two gold mines at Balmertown. Samples from street trees and residential vegetable gardens indicated, however, that arsenic was at or near normal concentrations in the townsite.

There were 83 sulphur dioxide readings above the maximum acceptable limit in 1981, about the same as in 1980. Vegetation damage caused by this pollutant occurred in a 12-hectare area, mostly on property owned by the mines. A sulphur dioxide emission reduction programme is being implemented in 1982.

DRYDEN

Dustfall continued to be recorded at levels substantially in compliance with Ontario regulations, as a result of emission control equipment commissioned at a local kraft pulp mill in 1977.

Concentrations of offensive odours frequently exceeded the Ministry guideline. Provisions of a Control Order specify that emissions of reduced sulphur compounds, the cause of the odour problem, must be abated by mid-1984.

FORT FRANCES

In the vicinity of a kraft pulp mill in Fort Frances, vegetation damage was still evident in 1981, but in a smaller area than previously recorded and almost totally confined to the mill's "buffer zone." The presence of malodorous gases and fallout of particulate matter continued to be a problem, although there was evidence of improvement in the latter during the second half of the year. The current Control Order specifies that Ontario standards for these two pollutants must be met before the end of 1983.

Some vegetation injury, both on and off company property, was also found near the mill's secondary treatment system (lagoon). Operations of this system are under continuous review by the company and the Ministry to develop the best possible control of windblown foam. Unpleasant odours from the system's settling basins may persist until odour and spill controls at the mill are completed.

KENORA

An upset condition at a sulphite pulp mill released a quantity of sulphur dioxide in late June which caused vegetation damage in a small area nearby. Changes in equipment and operating procedure were made to prevent a recurrence. When the present sulphite-groundwood mill is converted to a combination thermal mechanical and chemical mechanical process, as now proposed, emissions of sulphur dioxide will be significantly reduced.

Fallout of char material from the mill's boiler plant continued to be an occasional nuisance to area residents. This situation may continue intermittently until 1987, when boiler plant operations must fully comply with Ministry regulations.

MARATHON

Sulphation measurements in 1981 were similar to those in 1980 and indicated generally satisfactory levels of airborne sulphur compounds. To obtain specific concentrations of total reduced sulphur, the Ministry is planning to install a continuous monitor in 1982.

RED ROCK

Based on dustfall measurements and data from sulphation plates and a TRS monitor, fallout of particulate matter and concentrations of offensive odours continued to be well above acceptable levels in the vicinity of a kraft pulp mill in Red Rock. A new recovery furnace for the mill, now nearing completion, should soon result in significant improvement in local air quality.

TERRACE BAY

To support a Control Order issued to a local kraft pulp mill, a small air quality monitoring network consisting of a continuous total reduced sulphur monitor and seven sulphation measurement devices was established in late 1981. Because of a major fire which forced the mill to suspend production in late October, the air quality data collected by the Ministry for the year showed only normal background concentrations.

THUNDER BAY

Dustfall, at 9 of 10 sites, and total suspended particulate matter, at 5 of 6 sites, met the provincial air quality objectives for annual averages. This achievement is the result of a multi-million dollar dust control programme at local grain elevators, which has decreased dust levels in the city's air by about 40% to 50% in the past 8 years.

None of the maximum acceptable limits for sulphur dioxide (1-hour, 24-hour, or annual averages) were exceeded at any of the nine monitoring locations in Thunder Bay and environs.

Total reduced sulphur near a kraft pulp mill violated the Ministry guideline 72 times in 1981. Abatement action is expected to improve this situation in the near future.

Concentrations of ozone, a pollutant usually associated with long-range transport, met Ontario's air quality objective at all times.

Summaries are provided for four special studies conducted during the year in the Thunder Bay area.

INTRODUCTION

PURPOSE OF MONITORING PROGRAMME

The Ontario Ministry of the Environment operates an air quality assessment programme throughout the province to measure the levels of air pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. This programme documents compliance with air quality objectives, evaluates the need and effectiveness of pollution controls, and determines long-term trends in air quality.

In northwestern Ontario, the first air quality monitoring device was installed in the City of Thunder Bay in 1963 to measure concentrations of suspended particulate matter. Since then, monitoring capability has expanded to eight pollutants, and the network has increased to over 90 instruments in nine regional communities. Ontario Hydro also operates comprehensive monitoring networks in Thunder Bay and Atikokan. Data from air quality instruments are supplemented by information from vegetation, soil and snow sampling studies, and by predictions of pollutant concentrations with mathematical models.

Monitoring in the region is concentrated in urban areas, in areas where there have been pollution problems in the past, and in the vicinity of industrial sources of air pollution (mining, and pulp and paper). Therefore, evidence of undesirable air quality documented in this report should not be interpreted as typical of the region as a whole, where air quality is generally excellent.

In recent years, acidic precipitation has become a major environmental issue in eastern North America and parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study (APIOS) has mounted a comprehensive, long-term programme to assess the effects of acidic deposition and to develop possible solutions to this problem. The Ministry's Northwestern Region is an active participant in this programme, and is involved in precipitation monitoring surveys and research on the aquatic and terrestrial effects of acid rain. The findings of these studies will be reported elsewhere.

Future objectives of the air quality assessment programme in northwestern Ontario are to expand the monitoring network to all communities where pulp and paper mills are situated and to upgrade the collection and processing of air quality data through the implementation of a region-wide telemetry system.

POLLUTANTS AND THEIR MEASUREMENT

In this section, only those contaminants routinely monitored in northwestern Ontario will be considered. Carbon monoxide, nitrogen oxides and hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

Particulate Matter

There are many man-made and natural sources of particulate matter. Typical man-made sources in northwestern Ontario are grain elevators, forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Naturally-occurring particulate matter may also originate from forest fires, volcanic eruptions, and dust storms. Depending on particle size and chemical makeup, particulate matter may be injurious to health and vegetation, may adversely affect visibility, and cause local nuisance problems. In northwestern Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), or soiling index.

Dustfall represents fallout of particulate matter that settles out from the atmosphere by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed. The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ days (grams per square metre for 30 days), and the objective for the annual average is 4.6 $g/m^2/30$ days. Dustfall monitoring provides an estimate of fallout of particulate matter from local sources, including dust from nearby construction, or vehicle traffic on

dusty roads. Suspended particulate matter comprises particles of small size which remain entrained in the air for extended periods and which may originate from local or distant sources. It is measured for a 24-hour period every sixth day with a standard high-volume sampler (1). The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$, (micrograms per cubic metre of air) averaged over 24 hours, or 60 $\mu g/m^3$, annual geometric mean. Soiling index is a measure of the soiling or darkening properties of suspended particulate matter, and there is evidence that it is closely related to the concentration of respirable particulate matter. A measured volume of air is drawn through a paper tape which is advanced through an automated sampling unit to produce a sample every two hours. The reduction of light transmitted through the tape is expressed as a coefficient of haze (COH) per 1000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

Gaseous Pollutants

Sulphur Dioxide

Gaseous pollutants currently monitored in northwestern Ontario include sulphur dioxide, total reduced sulphur, fluoride, and ozone. Sulphur dioxide (SO_2) is one of the world's major atmospheric pollutants and has many well-documented adverse effects on human health, vegetation and property. It is also one of the principal contributors to the formation of acidic precipitation. In northwestern Ontario, the principal sources of SO_2, which are small in comparison to some other areas of the province, are the Ontario Hydro Thunder Bay generating station, sulphite pulp mills, industrial boilers and gold ore roasting. SO_2 is monitored either with passive samplers (sulphation plates), which provide a semi-quantitative estimate of the presence of sulphur-containing gases, or with continuous analyzers which measure

sulphur dioxide specifically. There are three air quality objectives for this pollutant: 0.25 ppm (parts of sulphur dioxide per million parts of air, by volume), hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

Total Reduced Sulphur

Total reduced sulphur (TRS) comprises a group of sulphur-containing gases commonly associated with emissions from kraft pulp mills, which are the sole significant TRS source in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary respiratory irritation or may injure vegetation. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air, by volume), averaged over one hour, is used as an air quality objective in the vicinity of kraft pulp mills. Measurement of TRS is conducted with sulphation plates, for semi-quantitative results, or with automated analyzers to record TRS continuously.

Ozone

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a secondary product of reactions between nitrogen oxides and hydrocarbons and, if present at elevated concentrations, may be detrimental to health and injurious to vegetation. Since the ingredients for ozone formation are not emitted in large quantity in northwestern Ontario, the occurrence of elevated ozone readings would implicate long-range transport from a distant source outside the region. Ozone is monitored with continuous analyzers and the current air quality objective is 0.08 ppm, averaged over one hour.

Fluoride

In northwestern Ontario, a brick and tile manufacturing facility near Thunder Bay is the only known significant industrial source of airborne fluoride. Fluoride may cause vegetation

damage or injury to livestock which has consumed forage with high fluoride content. Fluoride in air is monitored with passive samplers (lime candles) which provide an estimate of average monthly fluoride levels. The amount of fluoride formed by the interaction of hydrogen fluoride with lime-impregnated filter paper is expressed as µg F/100 cm^2/30 days (micrograms of fluoride per 100 square centimetres of filter paper exposed for 30 days). The air quality objective is 40 µg F/100 cm^2/30 days for the growing season (May to September) and 80 µg F/100 cm^2/30 days for the rest of the year.

Miscellaneous

The presence and effects of some of the foregoing pollutants, as well as additional ones, are also assessed by documenting vegetation injury symptoms and by determining contaminant concentrations in vegetation, soil and snow. Standard Ministry procedures (2, 3, 4) are followed in the collection and analysis of these types of sample material. Arsenic, chloride, fluoride (5), sulphur and heavy metals are typical contaminants examined by these techniques. Concentrations determined by analysis are compared with known normal background levels for the element under study.

Dustfall, sulphation, and suspended particulate matter determinations, as well as most analyses for vegetation, soil and snow are performed at the Ministry's Thunder Bay laboratory. Metals, nitrate and sulphate in suspended particulate matter, and sulphur and halides in vegetation and soil are analysed at the Ministry's central laboratory in Toronto. The central laboratory also provides a service for the determination of unusual contaminants (e.g. some organic compounds).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality data for the region.

RESULTS AND DISCUSSION

ATIKOKAN

A long-term joint monitoring programme involving the Ministry, Steep Rock Iron Mines Limited and Caland Ore Company Limited was terminated in 1979, shortly before permanent closure of the two mines. The only surviving part of this survey in 1981 was the measurement of suspended particulate matter (TSP) at the Atikokan Weather Station, in support of a monitoring program around a power plant under construction in the vicinity.

Air Quality Data

During the year, the 24-hour air quality objective for TSP (120 $\mu g/m^3$) was exceeded only once in 55 samples, and the maximum value was 154 $\mu g/m^3$, recorded on April 10. The annual geometric mean was 26 $\mu g/m^3$, well below the maximum acceptable limit of 60 $\mu g/m^3$, and down from the average of 38 $\mu g/m^3$ in 1980.

Pluswood Manufacturing Limited

In response to complaints from area residents, a snow sampling survey was carried out around a particle board plant operated by Pluswood Manufacturing Limited in Atikokan. The investigation (6) showed that fine wood particles, and possibly some related organic compounds, were emitted from the plant in quantity sufficient to cause a local fallout nuisance.

Stack testing was recently completed by the company and a report is expected shortly. If any emission sources are shown to be exceeding Ministry standards, the company will be required to implement process modifications or to install additional air pollution control devices. A follow-up survey will be conducted to document the effectiveness of this abatement action.

Ontario Hydro Generating Station

In 1981, a comprehensive pre-operational air quality investigation began in the area surrounding the site of Ontario Hydro's thermal generating station. Fourteen locations (Figure 1) were

selected for vegetation, soil and snow sampling to complement the air quality monitoring programme undertaken by Ontario Hydro. By 1984, when the 200-megawatt plant is scheduled to be commissioned, at least three years of background data will have been collected.

Details of the work carried out by the Ministry in 1981 will appear in a separate report. A preliminary review of the data indicates evidence of residual contamination in vegetation and soil at some sampling locations, caused by historical iron ore mining activity. However, results from most sites represent normal background conditions.

The environmental assessment programme at Atikokan will continue for some years after the power plant begins operating. The Ministry fully expects that this study will demonstrate compliance with all environmental regulations and guidelines.

Acidic Precipitation

Because of strong concerns expressed about the effects of the Atikokan generation station on sensitive wilderness areas along the Ontario-Minnesota border, a significant portion of the Ministry's regional study of acidic precipitation is concentrated south of Atikokan in the vicinity of Quetico Provincial Park and the adjacent Boundary Waters Canoe Area in Minnesota. In 1981, three sites (Figure 1) were established in the area for long-term precipitation monitoring. Baseline soil samples were collected near these locations and at two additional points along the Quetico Park boundary. Sampling of many of the area's lakes has been undertaken since 1979 to determine their sensitivity to acid precipitation. Lake sensitivity assessment will continue in 1982, and other biological studies, including fish sampling, will also be carried out.

BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines at Balmertown since 1971. For many years, Campbell Red

Lake Mines Limited and Dickenson Mines Limited emitted significant quantities of arsenic trioxide and sulphur dioxide from ore roasting operations. In the mid-1970's, both mines installed controls to reduce arsenic emissions by more than 95 percent. In early 1980, Dickenson implemented process changes which permitted the termination of ore roasting at its mill.

Vegetation And Soil Assessment

Forest Area

Symptoms of acute sulphur dioxide (SO_2) injury were observed during the 1981 growing season on foliage of trees, shrubs and herbaceous plants in small scattered areas totalling 12 ha (hectares), on company property near the mines (Figure 2). Injury to rhubarb leaves in a few gardens on Dickenson Road was the only damage noted in the townsite. Vegetation injury at Balmertown varies from year to year, and depends on the right combination of pollutant concentrations, period of exposure, time of year, vegetation sensitivity, and other factors.

Samples of trembling aspen foliage from 26 sites around the mines (Figure 3) were analysed for arsenic and mercury. The results for arsenic were similar to those for 1980 (7), which showed that elevated arsenic persisted around both mines. A comparison with results from earlier years (Table 1) indicates that levels in 1981 were well below those found in 1975 and earlier, before controls were in place, but still well above normal background. Arsenic in forest trees at the perimeter of the townsite was near normal.

Mercury in aspen foliage was significantly elevated only in a very small area east of Campbell's roaster, where high values had been recorded in snow samples in 1978 and 1979.

Townsite Area

Arsenic in foliage from white elm (Ulmus americana) and Manitoba maple (Acer negundo) trees planted along roads in the

townsite continued near the background levels recorded in recent years, though a little above the concentrations found in 1980 (Table 2). Compared with the period before emission controls, arsenic concentrations in street trees in Balmertown declined approximately 99 percent.

Soil and vegetables from three residential gardens in Balmertown were collected and analysed for arsenic and mercury. The results for arsenic, in Table 3, showed a slight improvement over 1980: all samples of edible portions of garden vegetables were below the maximum limit specified by the Health Protection Branch, Canada Department of Health and Welfare. All samples were also well within the recommended international guideline for mercury. Since arsenic levels in soil remain high, vegetables from Balmertown gardens should be thoroughly washed before consumption.

Air Quality Data

Sulphur Dioxide (SO_2)

A summary of the readings obtained from the Ministry's continuous SO_2 analyzer in Balmertown is presented in Table 4, together with data for previous years. In 1980, the 1-hour air quality objective was exceeded 83 times, and the 24-hour objective six times. Both of these figures were significantly lower than those recorded in 1978 and 1979, when Dickenson's roaster was still operating. The annual average concentration, 0.013 ppm, was well below the maximum acceptable limit of 0.020 ppm. There was only one "potentially injurious fumigation" (PIF) recorded, on June 6. A PIF is defined as the occurrence, during daylight hours in the growing season, of average SO_2 concentrations at a level considered injurious to sensitive vegetation. There were six PIF's in 1978, three in 1979, and one in 1980. In 1981, many of the high SO_2 readings occurred during the early months of the year, before the growing season.

At the concentrations recorded, sulphur dioxide might occasionally be noticed as a disagreeable odour by local residents, but no adverse health effects would be expected. Periodic injury to vegetation will likely occur. Campbell Red Lake Mines has

implemented a Voluntary Emission Reduction Programme (VERP), under which the company's roaster will be shut down during periods when roaster stack emissions would be carried toward the townsite. This action is expected to reduce SO_2 concentrations in the townsite area and should avoid potential vegetation damage.

DRYDEN

For several years, the Ministry has monitored air quality in Dryden to assess the effects of emissions from a bleached kraft pulp mill and associated chlor-alkali chemical plant. Past studies demonstrated that mercury, particulate matter, and offensive odours in the vicinity of the mill were often significantly above normal concentrations. However, abatement action and process changes implemented in the mid to late 1970's successfully dealt with emissions of mercury and particulate matter. In 1981, the Ministry's monitoring programme was confined to a continuation of dustfall and odour measurements.

Air Quality Data

Dustfall

At five of the six monitoring sites in Dryden (Figure 4) where dustfall is monitored (Figure 4), the annual average met the Ontario air quality objective in 1981. Dustfall levels recorded in the past 4 years have shown little variation since the company completed a major dust emission control programme in 1977. Except for minor amounts of wood fines and bark char, emissions from mill operations do not contribute to fallout of particulate matter in the town. Dustfall measurements will continue at least until 1983, when a modernization and expansion of kraft pulp production facilities is scheduled for completion.

Sulphation Rates

The past record of sulphation rates in Dryden is summarized in Table 6. Average sulphation decreased from 1980 to 1981, indicating a reduction in levels of odorous sulphur gases in the air.

Total Reduced Sulphur (TRS)

Continuous readings of total reduced sulphur are obtained by an automated analyzer at 56 King Street. A summary of the data (Table 7) supports the finding from sulphation monitoring that there was a modest improvement in 1981 in the overall average TRS concentration. However, the occurrence of 405 hours of data above the 27 ppb guideline demonstrated that concentrations of offensive odours still frequently occurred at unacceptable levels. The maximum 1-hour average during the year was 190 ppb, approximately seven times the guideline. No significant improvement is expected until odour emissions from the mill are abated. Although the Control Order does not require odour control before the end of June, 1984, significant improvement is expected by the end of 1982 after the new kraft mill is in operation.

FORT FRANCES

Emissions from a bleached kraft pulp mill in Fort Frances have resulted in excessive fallout of particulate matter, high concentrations of malodorous gases, vegetation damage, and complaints from nearby residents. Since 1971, when the kraft mill was constructed, a "buffer zone" has been developed through purchase of residential property adjacent to the mill. Some emission reductions were also achieved and, in 1980, a Control Order was issued to enforce compliance with Ministry regulations.

Air quality assessment investigations in Fort Frances have been conducted regularly since 1972 in the vicinity of the Canadian mill and a similar kraft mill owned by the parent corporation on the U. S. side of the border (Figure 5). In 1981, this programme included studies around a secondary treatment system for liquid effluent from the Fort Frances kraft mill.

Vegetation and Snow Sampling

Mill Area

Tree and shrub vegetation near the kraft mill was examined in August, and the injury zone ascribed to mill emissions was judged to be only 3.8 ha in 1981, the smallest since detailed records began in 1974. The area with damaged vegetation was restricted almost entirely to the portion of the company's buffer zone on the north side of the mill. Some trees in this area continued to decline, due to exposure over several years to several pollutants emitted from the mill.

Sodium and chloride concentrations in Manitoba maple foliage sampled from 23 sites (Figure 5) are shown in Table 8. Sodium and chloride levels were above normal only in or adjacent to the "buffer zone."

Lagoon Area

Air pollution injury to shrubs and trees was first noted in 1980 in the immediate vicinity of the south side of the mill's secondary treatment system (lagoon) on Eighth Street, 1.5 km northwest of the kraft mill (Figure 6). Drift from spray guns used to suppress foam on the lagoon was determined as the cause of damage, and the guns were subsequently moved to the north end of the lagoon. In 1981, new vegetation injury was found in an area of about 11 ha, half off company property, along the north and east sides of the lagoon. Chloride and sodium concentrations were very high in damaged tree foliage, and spray drift was again implicated as the cause. Further details are provided in a separate report (8).

Snow samples collected in February from 10 sites near the lagoon showed no evidence of contamination (8), a finding which indicates that no fallout occurs near the lagoon under winter conditions. Bags of Sphagnum moss exposed during August at 12 sites near the south end of the lagoon contained normal levels

of chloride and sodium. Chloride in moss declined significantly from 1980, when the spray guns were still in use at the south end of the lagoon (8).

Air Quality Data

Dustfall

As shown in Table 9, average dustfall did not change significantly from 1980 to 1981. In 1981, nearly half the monthly values exceeded the air quality objective, and five of the seven annual averages were also above the maximum acceptable limit. At the four sites near the mill (stations 62030, 33, 36 and 46), three of which are now in the "buffer zone," wood fines accounted for an estimated 40 percent of total dustfall and sometimes nearly 100 percent of insoluble dustfall. At the same locations, about 25 percent of total dustfall was saltcake. It is also recognized that while road dust periodically contributed significantly to dustfall at many of the monitoring sites, sawdust and saltcake remain the principal components of dustfall consistently found from year to year near the mill. Most of the high dustfall readings occurred in the first half of the year, with a notable decline thereafter as a result of abatement action taken by the company to reduce emissions of wood fines.

Excessive fallout of particulate matter is to be resolved before the end of 1983, the deadline specified in a Control Order issued to Boise Cascade in 1980. In addition, the company acquired additional residential property in 1981, on the north side of Sinclair Street between Portage and Victoria Avenue, to add to its established "buffer zone."

Suspended Particulate Matter (TSP)

Concentrations of TSP at the site nearest the mill (station 62030) exceeded the 24-hour air quality objective during 19 sampling periods in 1980. Wood fines, emitted from the mill's wood chip processing system, were sometimes observed on sample filters. The annual geometric mean was 74 $\mu g/m^3$, the same as for

1980, and somewhat above the level (60 $\mu g/m^3$) considered desirable. At station 62032, in the Fort Frances Cemetery, the 24-hour objective was exceeded in only three of 58 samples and the annual mean, 39 $\mu g/m^3$, was similar to that recorded for several years at this location. Highest readings at both stations were associated with prevailing wind from the south.

Sulphation Rates

Although the 1981 sulphation data show improved air quality over 1980 (Table 10), these results do not agree with the records from our TRS monitor at Church and Portage. The reason for this difference is not clear. One possible explanation is that the sulphation plates were prepared and analyzed at different laboratories in 1980 and 1981.

Total Reduced Sulphur (TRS)

The TRS results for the year indicate a decline in air quality from 1980. The annual average concentration of TRS at station 62030, near the mill, increased from about 9 ppb to 12 ppb, and the frequency of hourly averages above the 27 ppb guideline (12 percent) was higher than the 10 percent recorded in 1980 (Table 11). A plot of hourly average concentrations for 1981 at this location is shown in Figure 7. The highest TRS levels recorded near the mill might occasionally cause temporary discomfort to local residents.

The frequency of TRS levels above the guideline at station 62032, in the Fort Frances Cemetery, also increased from 1980, as did the maximum hourly reading. The annual average was about the same.

Analysis of TRS data by wind direction (Table 12) revealed that all the high readings occurred when the two monitors were downwind of the nearest pulp mill. For station 62030, average TRS concentrations increased in 1981, compared to 1980, when the monitor was downwind of the mill. Average concentration under calm conditions also rose. No change was experienced at

station 62032. The low, but detectable, readings with northwest winds at station 62030, and north winds at station 62032, were attributed to odours from the company's secondary treatment system on Eighth Street.

The increased odour levels monitored at station 62030 in 1981 are at least partly due to a higher percentage of downwind conditions: the monitor was downwind of the Fort Frances mill less than 15 percent of the time in 1980, compared with more than 18 percent in 1981. Because pulp production at the mill was at a high level in 1981, odour emissions may also have been higher during the year. In any case, the existing Control Order calls for the odour abatement to be completed by the end of 1982.

KENORA

Air quality studies have been conducted by the Ministry for the past 11 years around a sulphite pulp mill in Kenora. In the past, sulphur dioxide emissions from this source caused periodic vegetation damage, but this problem was corrected several years ago. Fallout of particulate matter from the mill's power boiler stack has continued to be an occasional nuisance to nearby residents.

Vegetation Assessment

An upset condition in the sulphite mill on June 30 led to excess emissions of sulphur dioxide and gave rise to complaints from nearby residents of offensive odours, temporary breathing difficulty and vegetation damage. Eight complaints of vegetation injury were investigated. A total area of just under 7 ha of vegetation damage was involved (Figure 8). Following this incident, changes in equipment and operating procedures were made at the mill to prevent a recurrence of a similar situation.

Air Quality Data

Dustfall

Dustfall in 1981 (Table 13) exceeded the annual objective significantly at one site (station 61007), slightly to moderately at two sites (stations 61003 and 61009) and was acceptable at the fourth monitoring location (station 61008). High readings at station 61007 (Figure 9) were caused mainly by char material emitted from the mill's power boiler stack. Char was also a contributor to dustfall at other sites, notably station 61009. Lignite ash was also identified in dustfall from stations near the mill, but did not account for more than 10 percent of total dustfall. Changes implemented in fuel mixtures for the mill's coal burning boilers should ensure that fly ash emissions are insignificant. Bark or lignite char might cause minor fallout episodes until 1987, when a Control Order requires that all boiler plant operations meet Ministry regulations. Char and lignite ash fallout do not cause any known health hazard or other injurious effect.

Sulphation Rates

Sulphation rates were about the same in 1981 as in 1980. The highest reading occurred at station 61007 in July, following unusual SO_2 emissions which caused vegetation damage. Under normal conditions, the Ministry believes the mill operates in compliance with Ontario regulations. After 1985, when Boise Cascade plans to convert the mill to a new process, SO_2 emissions will be largely eliminated.

MARATHON

Air quality investigations at Marathon, which began in 1974, have examined concentrations and effects of airborne mercury, particulate matter, and gaseous sulphur compounds in the vicinity of a bleached kraft pulp mill and adjacent chlor-alkali plant. All surveys showed that, with the exception of sulphur compounds,

emissions from these sources had negligible impact in the townsite area, 500 to 1,000 metres to the east. Because this situation was well documented, only the measurement of sulphation rates was continued in 1981.

Air Quality Data

Sulphation Rates

Average sulphation rates for five sites in Marathon (Figure 10) and one in Heron Bay are summarized in Table 14. Except for a significant drop in sulphation at station 63031, closest to the mill, results in 1981 were similar to those for 1980 (Table 14).

To obtain specific continuous measurements of TRS, the Ministry proposes to install a monitor for this pollutant in 1982. However, the American Can mill appears to be in substantial compliance with Ontario emission regulations at the present time.

RED ROCK

Surveys conducted since 1976 have established that a kraft pulp mill at Red Rock is a source of significant emissions of particulate matter and reduced sulphur. In 1978, the Ministry established a small network (Figure 11) of passive samplers in Red Rock to monitor local air quality. A continuous TRS analyzer was added in July, 1981 at station 63084, and wind recorders were installed at the same site in December.

Air Quality Data

Dustfall

Table 15 summarizes dustfall results for 1981 at four sites in Red Rock. The annual objective was met only at the site farthest from the mill. Sodium and sulphate, expressed as salt-cake (Na_2SO_4), accounted for about 25 percent of total dustfall

at the farthest station, and nearly 60 percent at station 63082. Char particles and wood fibres sometimes comprised a significant fraction (up to 50 percent) of dustfall.

A new recovery furnace and precipitator, now nearing completion, is expected to significantly reduce emissions of particulate matter in the latter part of 1982.

Sulphation Rates

The data in Table 16 indicate that average concentrations of airborne sulphur compounds have been roughly the same over the past three years, and that undesirably high odour levels occur periodically in the townsite.

Total Reduced Sulphur (TRS)

For the 5½ months of operation during 1981, the Ministry's newly installed TRS monitor located at the Red Rock Recreation Centre recorded TRS concentrations above the Ontario guideline during 289 hours (about 8 percent of the time). The maximum reading of 349 ppb was approximately 13 times the guideline. Concentrations at this level might cause temporary discomfort to area residents.

Significant reductions in both TRS and sulphation rates are expected when the mill's new recovery furnace and precipitator commence operation in late 1982.

TERRACE BAY

Beginning in 1976, the Ministry conducted several surveys to assess air quality in the vicinity of a kraft pulp mill in Terrace Bay. These investigations, comprising snow sampling and air quality measurements with mobile monitoring equipment, showed that fallout of particulate matter was not a problem in the townsite. However, levels of malodorous sulphur compounds were found to be above desirable concentrations around the mill, in the townsite, and at points where the effluent ditch from the mill crossed the nearby Trans-Canada Highway.

Air Quality Data

Sulphation Rates

To obtain long-term information on community odour concentrations, a network of sulphation monitoring sites (Figure 12) was selected in August and measurements began at these locations in October. During that month, sulphation above background levels occurred only at station 63090 (St. Martin School). Because of a major fire in the mill in late October, which terminated pulp production for several months, sulphation rates in November and December were low.

Total Reduced Sulphur (TRS)

A continuous TRS monitor was installed at St. Martin School in late November to obtain hourly readings of odour levels in the townsite. Because the pulp mill was closed, no measurable TRS was recorded from the date of installation to December 31. To alert the mill of pollutant concentrations above desirable levels, the company will install telemetering facilities between the monitor and the mill before January 31, 1983. A recently issued Control Order stipulates that odour emissions from the mill must comply with Ministry regulations by June 30, 1984.

THUNDER BAY

The Ministry maintained a 10-station air quality monitoring network during 1981 in Thunder Bay, down from 13 stations in 1980. The Ministry's 1981 network, plus the seven sites operated by Ontario Hydro, are shown in Figure 13.

In addition to routine monitoring at long-term stations, several special studies were also undertaken during the year. Brief summaries of these investigations are included in this report.

Air Quality Data

Dustfall

Dust emissions from grain elevators have historically been a nuisance problem in Thunder Bay, and dustfall measurements in the city began in 1970 with these sources in mind. The data for the 10 sites monitored in 1981 (Figure 13) are summarized in Table 17. Although the monthly objective was exceeded at least once at all but one site, the annual objective was met at all monitoring locations except the two near Great Lakes Forest Products Limited. Wood fibres sometimes occurred at significant levels at both these sites, and at one station, 63047, there was a sharp rise in dustfall in November and December following the commencement of coal burning in power boilers at Great Lakes. Fly ash and char were identified as major components of dustfall at 63047 during these two months. Alkaline constituents of substances emitted from Great Lakes were also considered responsible for the elevated pH of dustfall solutions at stations 63046 and 63047.

Figure 15 clearly shows the benefits from the multi-million dollar dust control programme at the city's grain elevators: in the past 9 years, average dustfall has declined nearly 50 percent. There was no change in average dustfall between 1980 and 1981.

Suspended Particulate Matter (TSP)

Of the six sites where TSP was measured, five met the objective for annual geometric mean (Table 18). Approximately 9 percent of the 348 samples exceeded the 120 $\mu g/m^3$ 24-hour objective, with most of the high values occurring in the spring. Filters from station 63046 (near Great Lakes Forest Products Limited) sometimes contained visible char particles and wood fibres. The bar graph in Figure 15 shows a trend similar to the one noted for dustfall: a progressive, significant decline in average TSP from 1973 to 1981. Now that the grain dust control programme is complete, no significant changes are expected in average dust levels throughout most of the city. Changes in climate, temporary disturbances such as construction activity near a monitoring

site, on emissions from some of the local forest products industries might periodically result in elevated levels of particulate matter.

Filters from two stations in the city centre (McKellar Hospital and St. Joseph's Hospital) are routinely analysed for heavy metals, nitrate and sulphate. In 1981, all metal concentrations (except iron in one sample) met Ministry regulations. Levels of nitrate and sulphate, thought due to long-range transport, exhibited much variation. Average concentrations of both these pollutants were higher in 1981 than in 1980.

Soiling Index

Soiling index, measured at St. Joseph's Hospital and 435 James Street South, was well within prescribed limits for 24-hour and annual averages. Soiling index levels have shown little change since monitoring began in 1976.

Sulphur Dioxide (SO_2)

Total emissions of SO_2 from industrial sources in Thunder Bay (principally the Ontario Hydro generating station and pulp and paper mills) are relatively small, and do not exceed 200 metric tons per day in total. The network of nine monitors (seven operated by Ontario Hydro and two by the Ministry) showed, as in 1980, full compliance for all sulphur dioxide air quality objectives.

During 1981, the first of two new lignite-fired units came into service at the generating station. The third unit will be commissioned in 1982. Because of the low sulphur content of lignite and the discharge of emissions from the new units through a tall stack, local air quality should not be adversely affected. When the old unit is also connected to the new stack in 1983, ground level concentrations of SO_2 should decrease still further.

Total Reduced Sulphur (TRS)

At the Ministry's monitoring station on Montreal Street (station 63046), the TRS guideline was exceeded during 72 hours in 1981. Comparable data for other years are shown in Table 20. The source of TRS, which causes offensive odours, is the Great Lakes kraft pulp mill, 1,100 metres from the monitoring site. In 1981, there was a reduction from the previous year in both the frequency of above-guideline readings and the maximum hourly average. The annual average showed little change. To reduce odour levels in the vicinity of its mill, the company is proposing to vent all odorous gases through the tall recovery furnace stack rather than low-level vents used at present.

Ozone (O_3)

Data for 1981 represent the first full year of ozone monitoring in Thunder Bay. As anticipated, highest readings at the Ministry's monitoring site at 435 James Street South (station 63040) were obtained during summer months, but the maximum value, 69 ppb, was below the air quality objective. Ozone concentrations in northwestern Ontario are not expected to reach the levels encountered in southern parts of the province.

Special Studies

Pulp Mills

Vegetation assessment inspections were again conducted around the three sulphite pulp mills in Thunder Bay. No air pollution injury was found.

Thunder Bay Terminals Limited

A report on air quality studies in the vicinity of Thunder Bay Terminals Limited showed that the coal terminal was operating satisfactorily, and that there was no increase in dust levels at sites off company property since coal shipments began in 1978 (9).

Thunder Tile Limited

Ministry surveys during the year showed little change in air quality in the vicinity of Thunder Tile Limited (formerly Thunderbrick Limited) in Rosslyn. Emissions from this source continued to result in elevated concentrations of fluoride in vegetation and to cause minor injury to sensitive plants (10). A Control Order requiring compliance with emission regulations was prepared by Ministry staff, but the company, for economic reasons, suspended operations before the Order was served.

Ontario Hydro - Thunder Bay Generating Station

A preliminary air quality study carried out in 1980 near the fly ash disposal site at Ontario Hydro's Thunder Bay thermal generating station showed that contaminant concentrations were low in experimentally exposed moss and in living vegetation close to the disposal area (11). Because of changes in the type of ash transported to the disposal site, further monitoring is being undertaken in 1982.

ACKNOWLEDGEMENTS

The assistance of staff of the following organizations is gratefully acknowledged: Atmospheric Environment Service, Atikokan Weather Station, for operating a high-volume sampler; Dingwall Medical Clinic, Dryden, for assistance in operating the TRS monitor; and Ministry of Industry and Tourism, Fort Frances, for assistance in operating the TRS monitor at station 62030.

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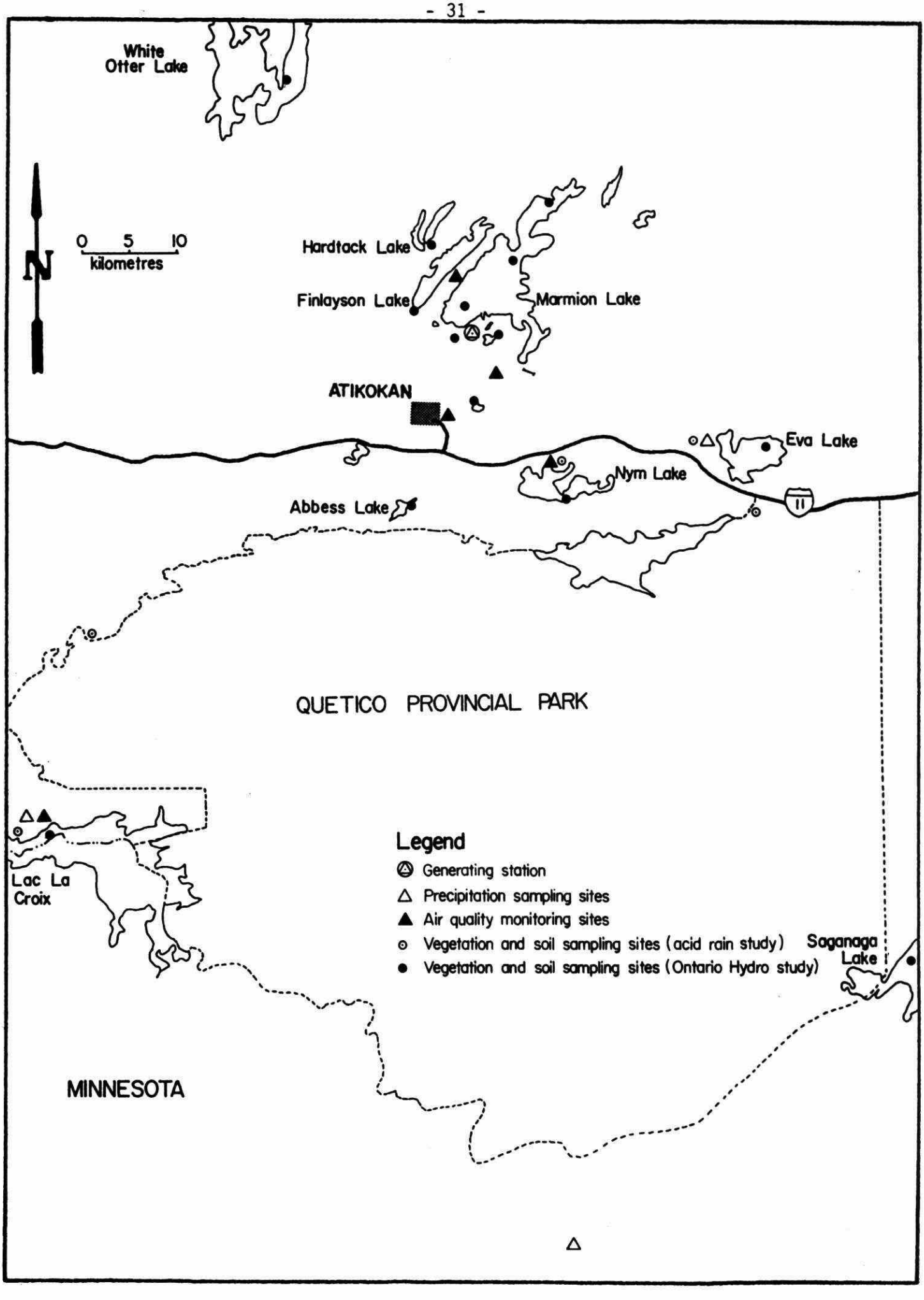

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

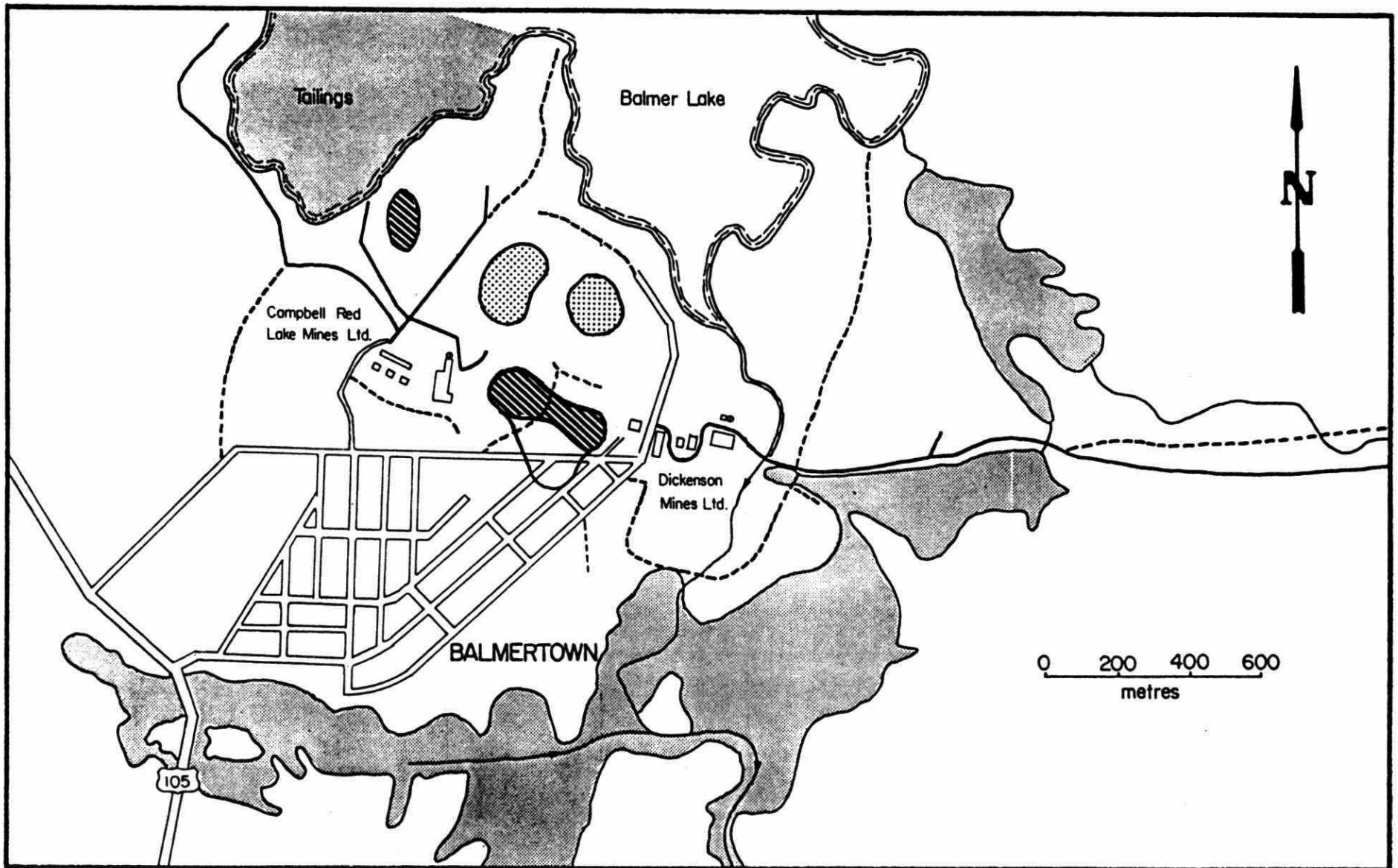

Figure 2. Areas of sulphur dioxide injury to vegetation, Balmertown, August, 1981.

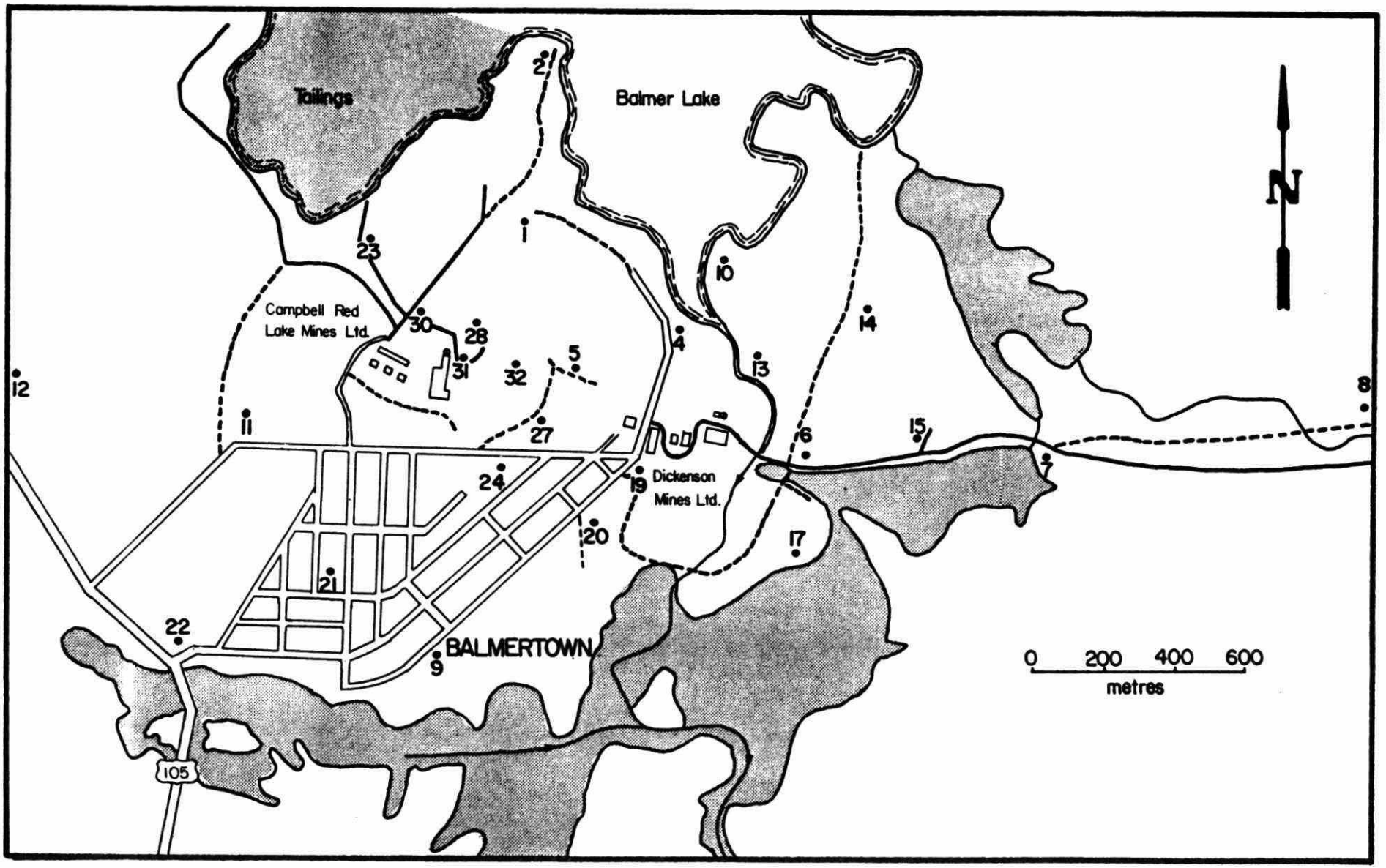

Figure 3. Trembling aspen sampling sites, Balmertown, 1981.

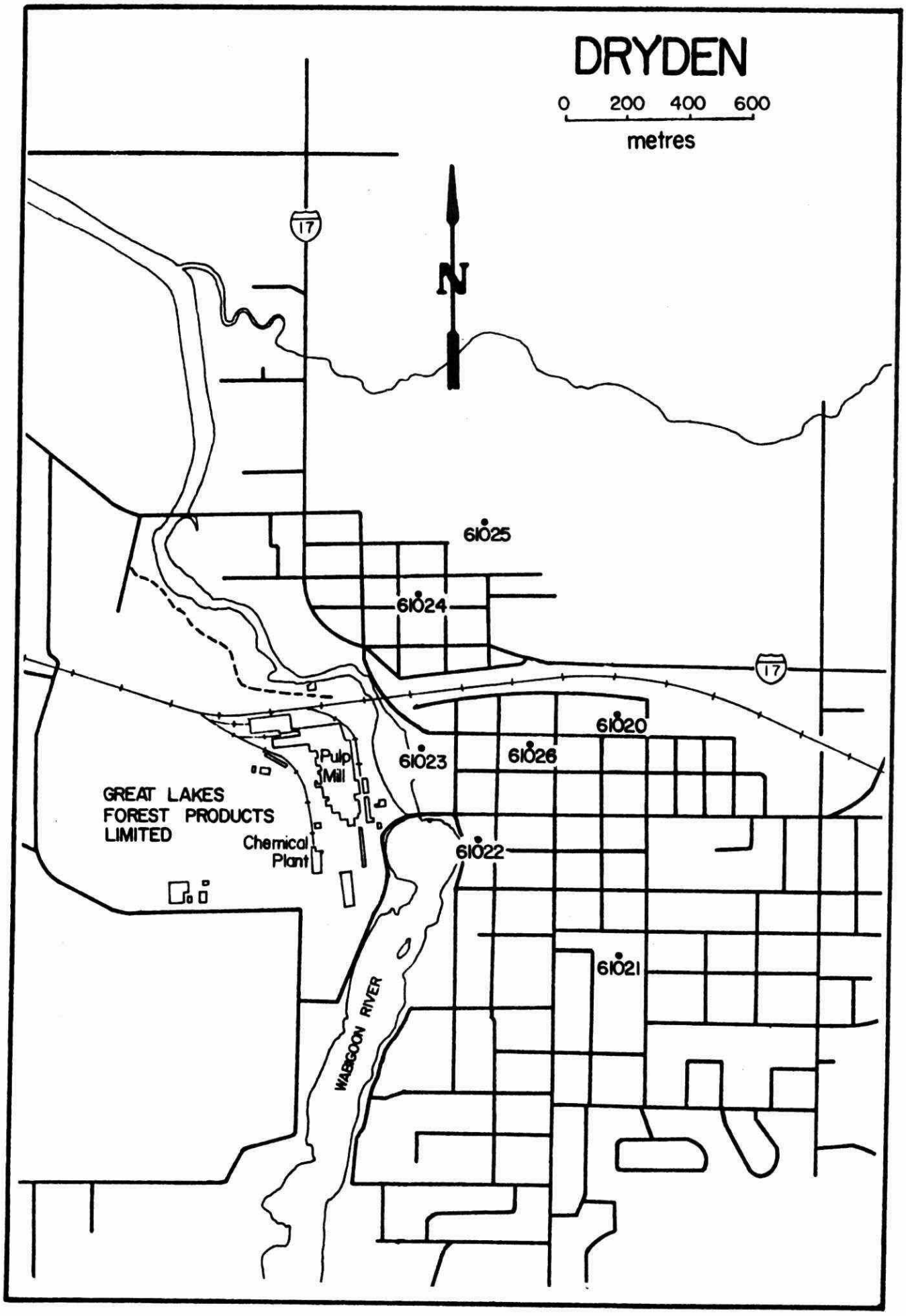

Figure 4. Air quality monitoring sites, Dryden, 1981. (TRS only at 61026)

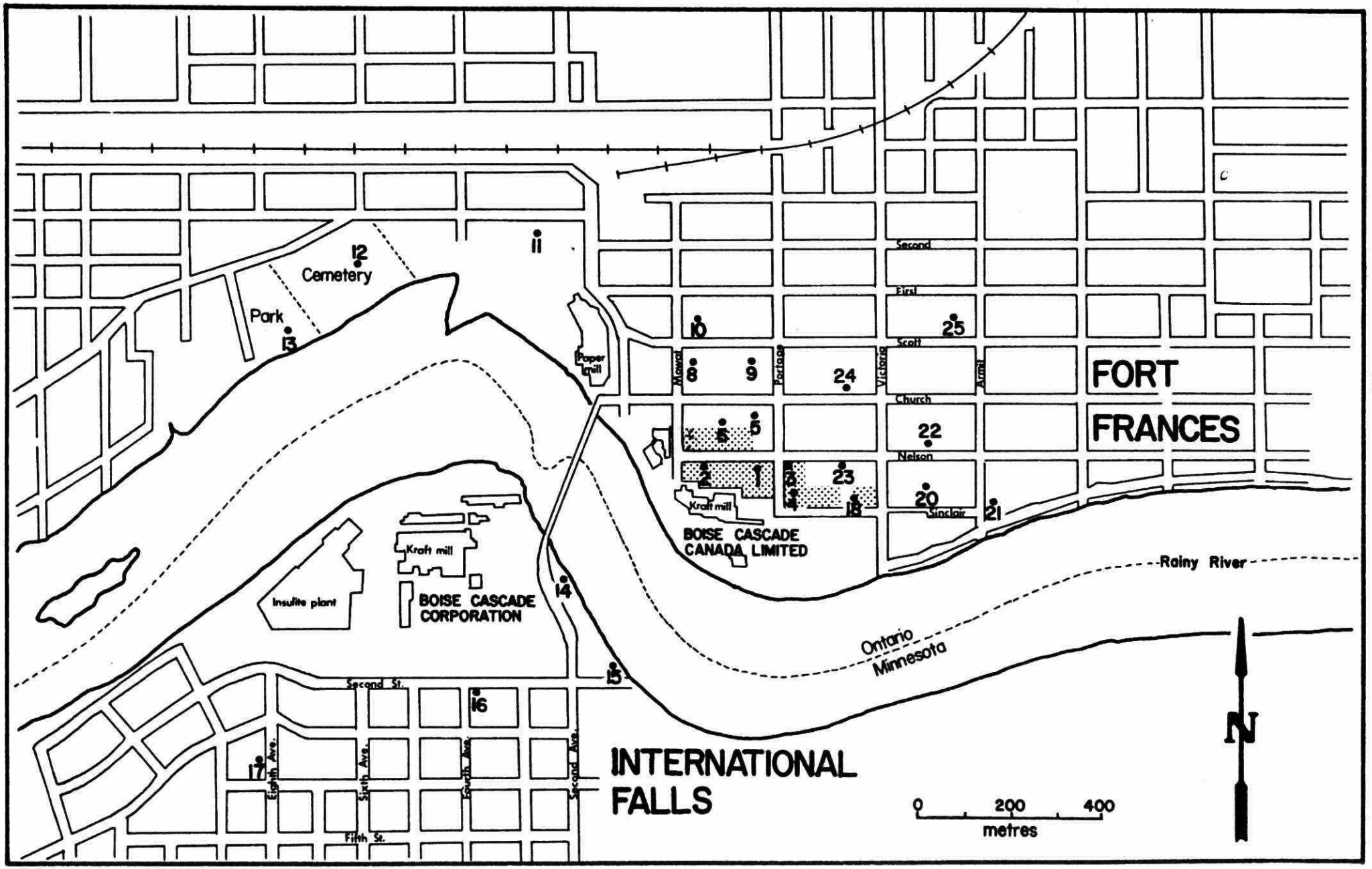

Figure 5. Manitoba maple sampling sites, 1981. Buffer zone

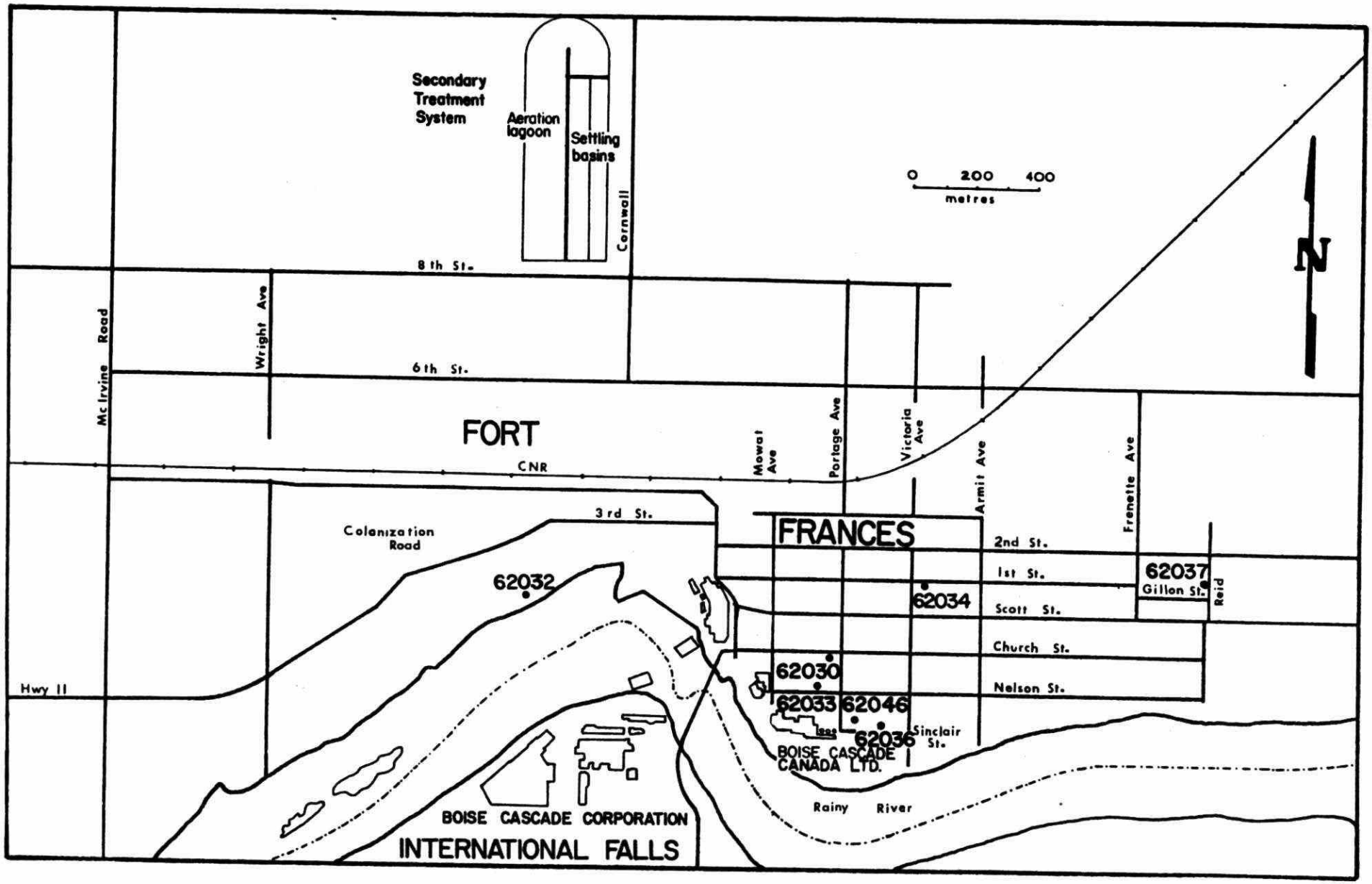

Figure 6. Air quality monitoring sites, Fort Frances, 1981.

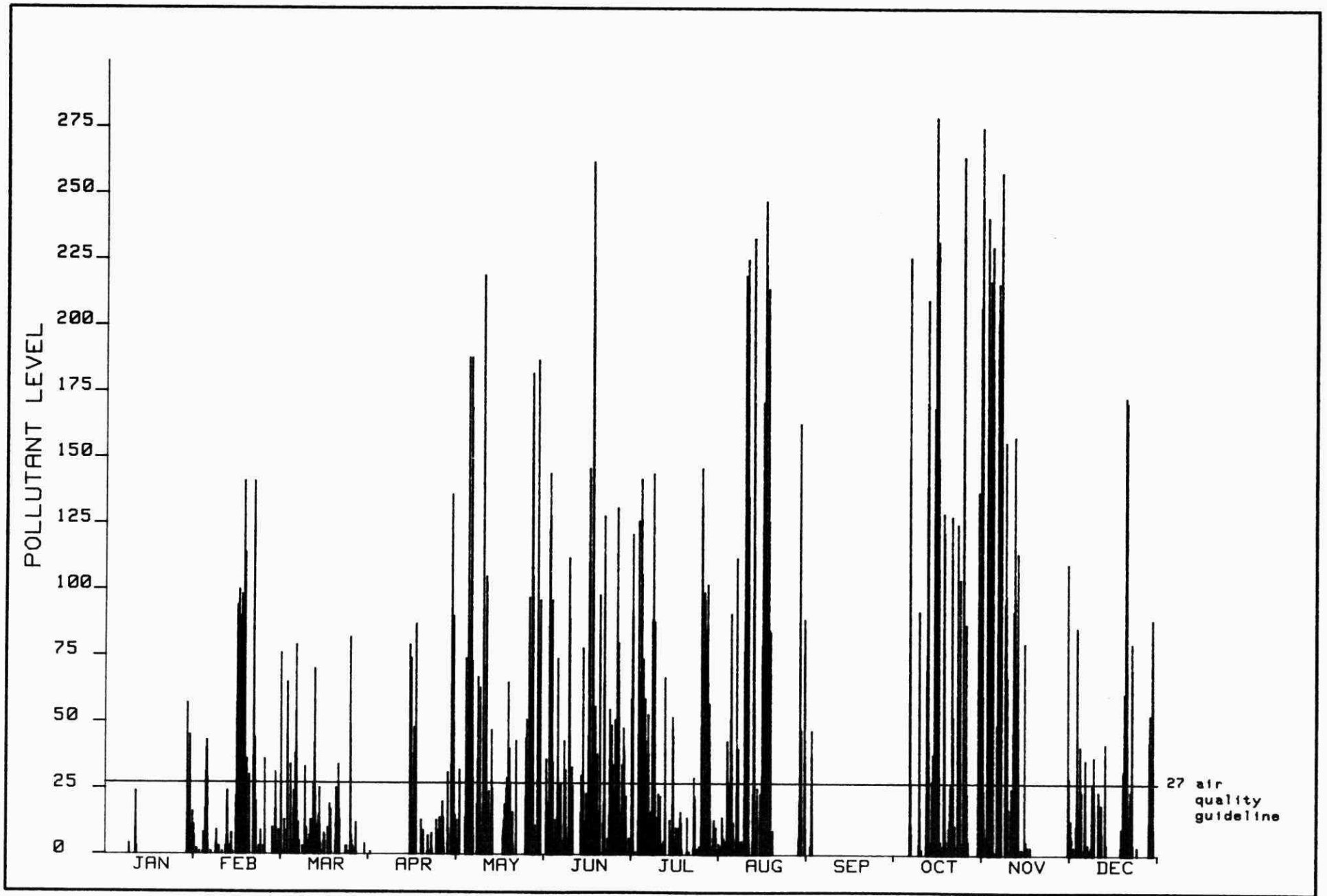

Figure 7 . Hourly average total reduced sulphur concentrations (parts per billion), station 62030, Fort Frances, 1981.

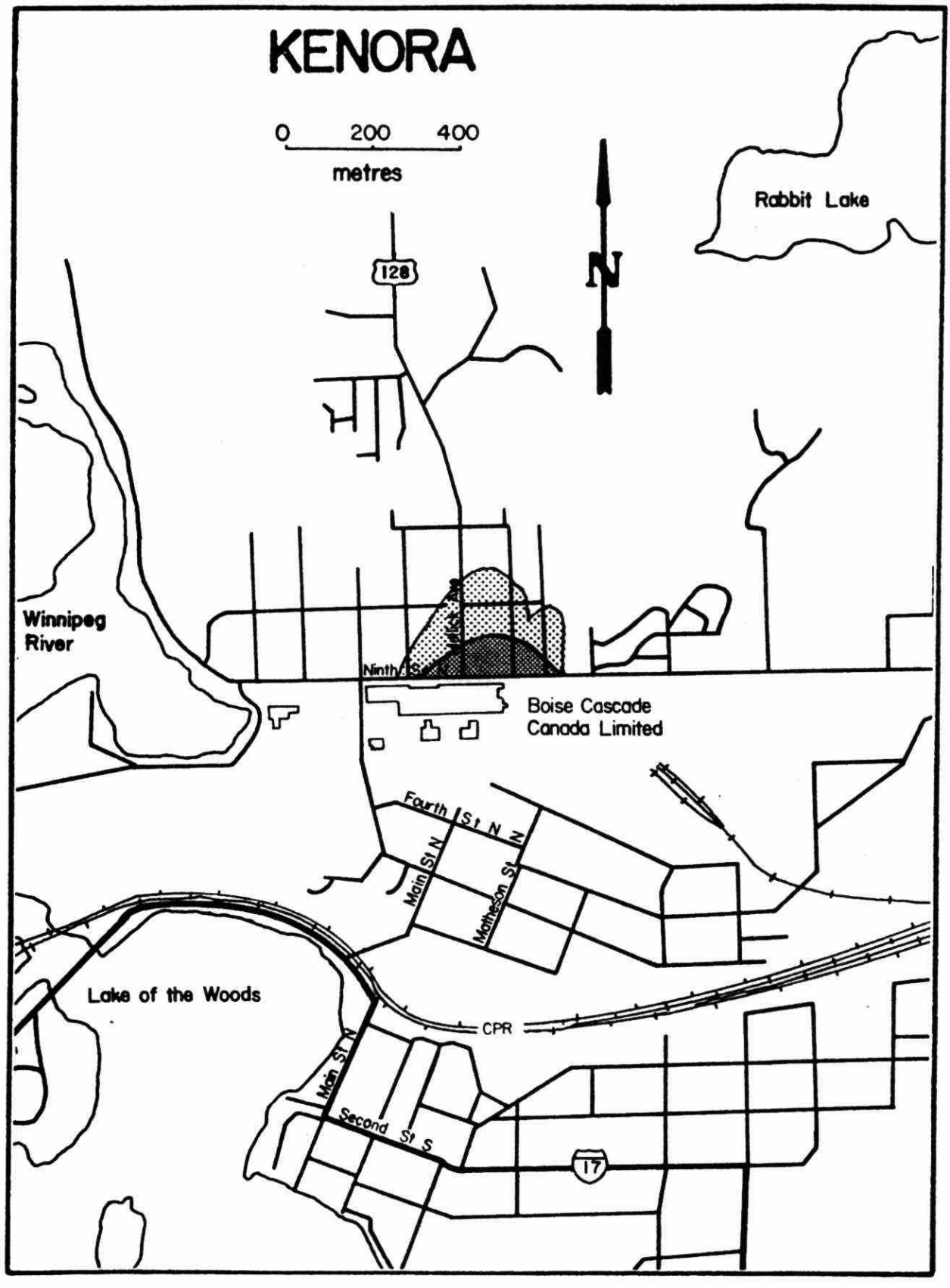

Figure 8. Area of sulphur dioxide injury to vegetation, Kenora, July, 1981.

Moderate to severe

Nil to light

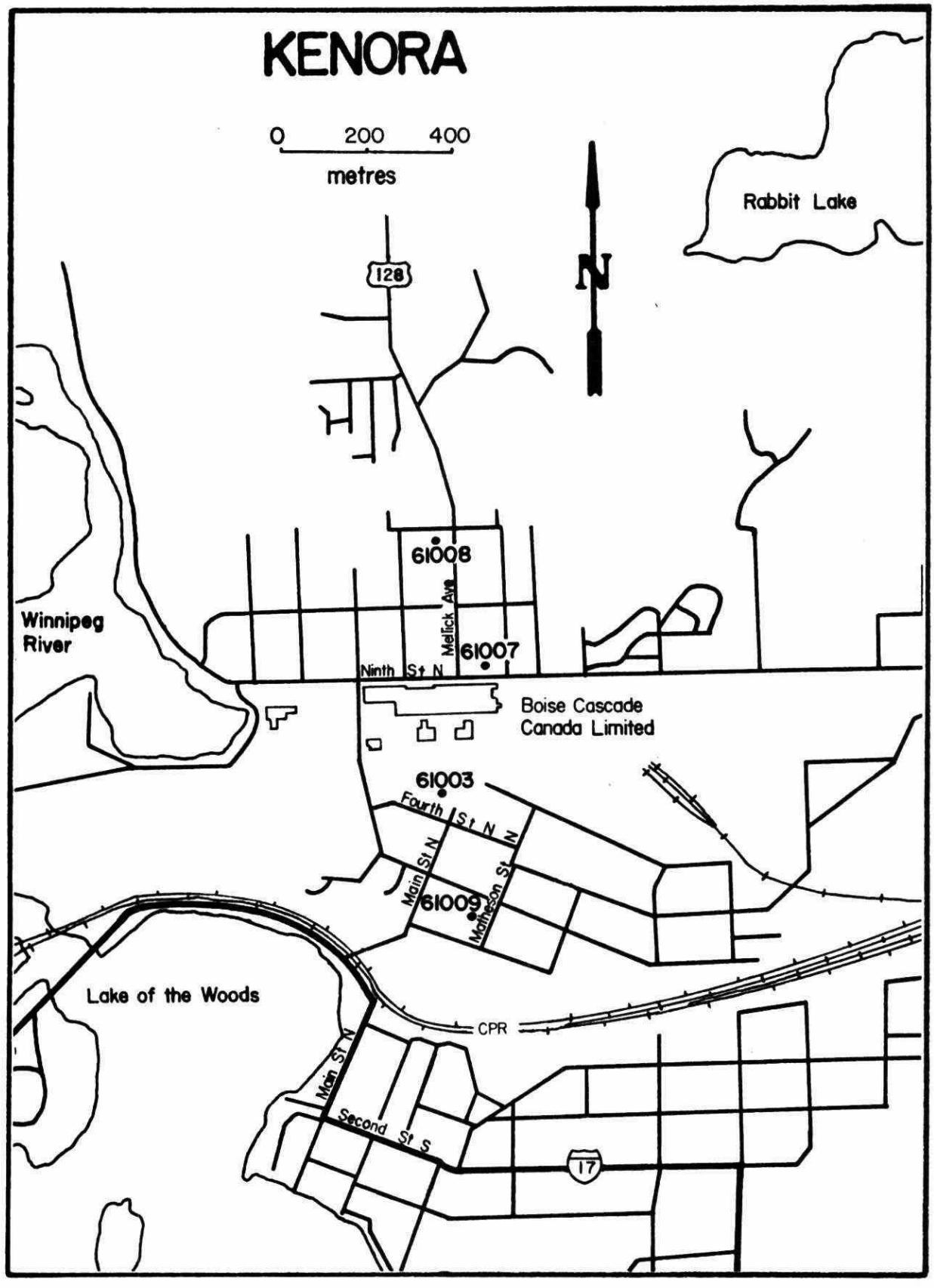

Figure 9. Air quality monitoring sites, Kenora, 1981.

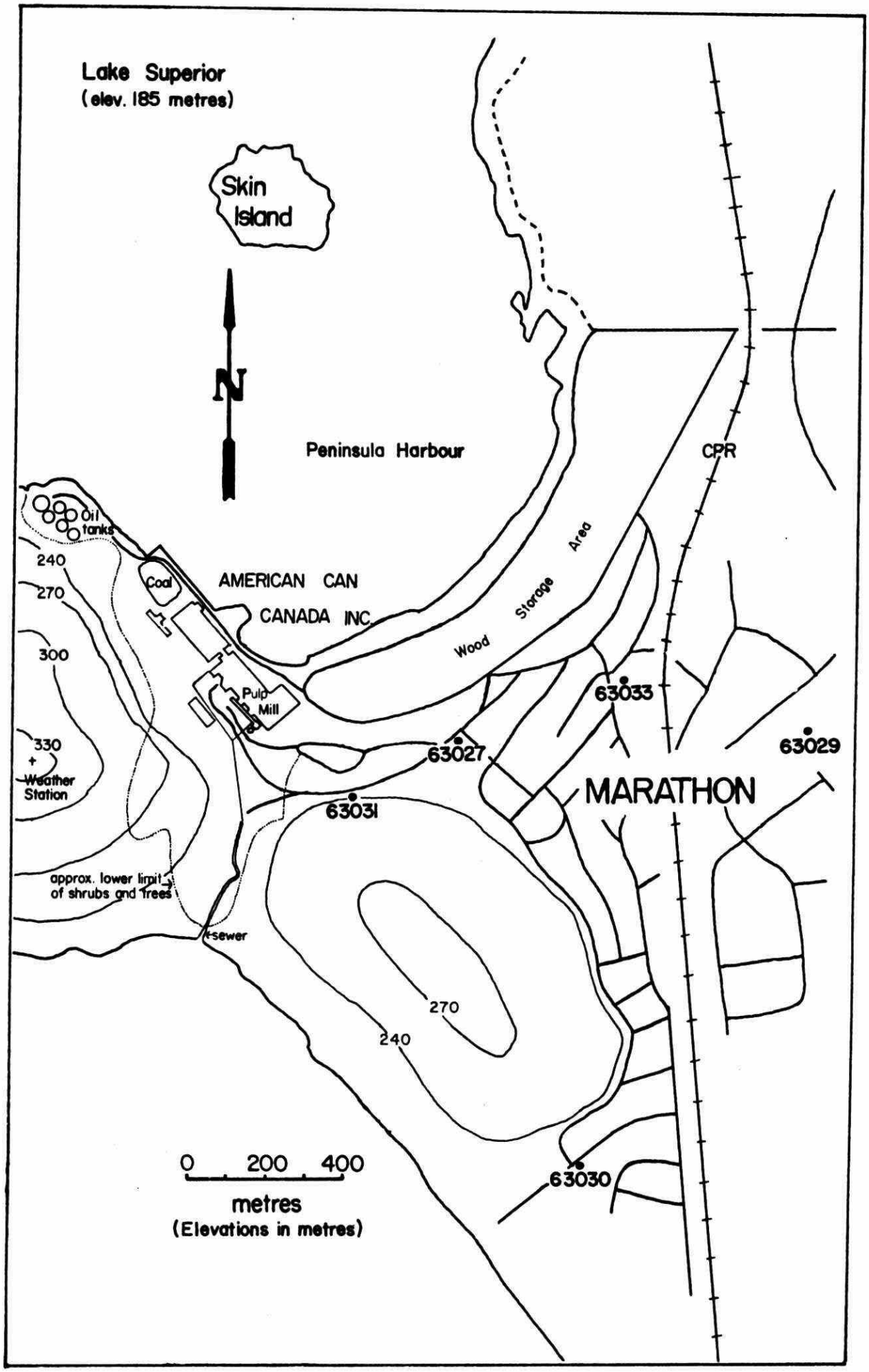

Figure 10. Air quality monitoring sites, 1981 (except station 63032, Heron Bay).

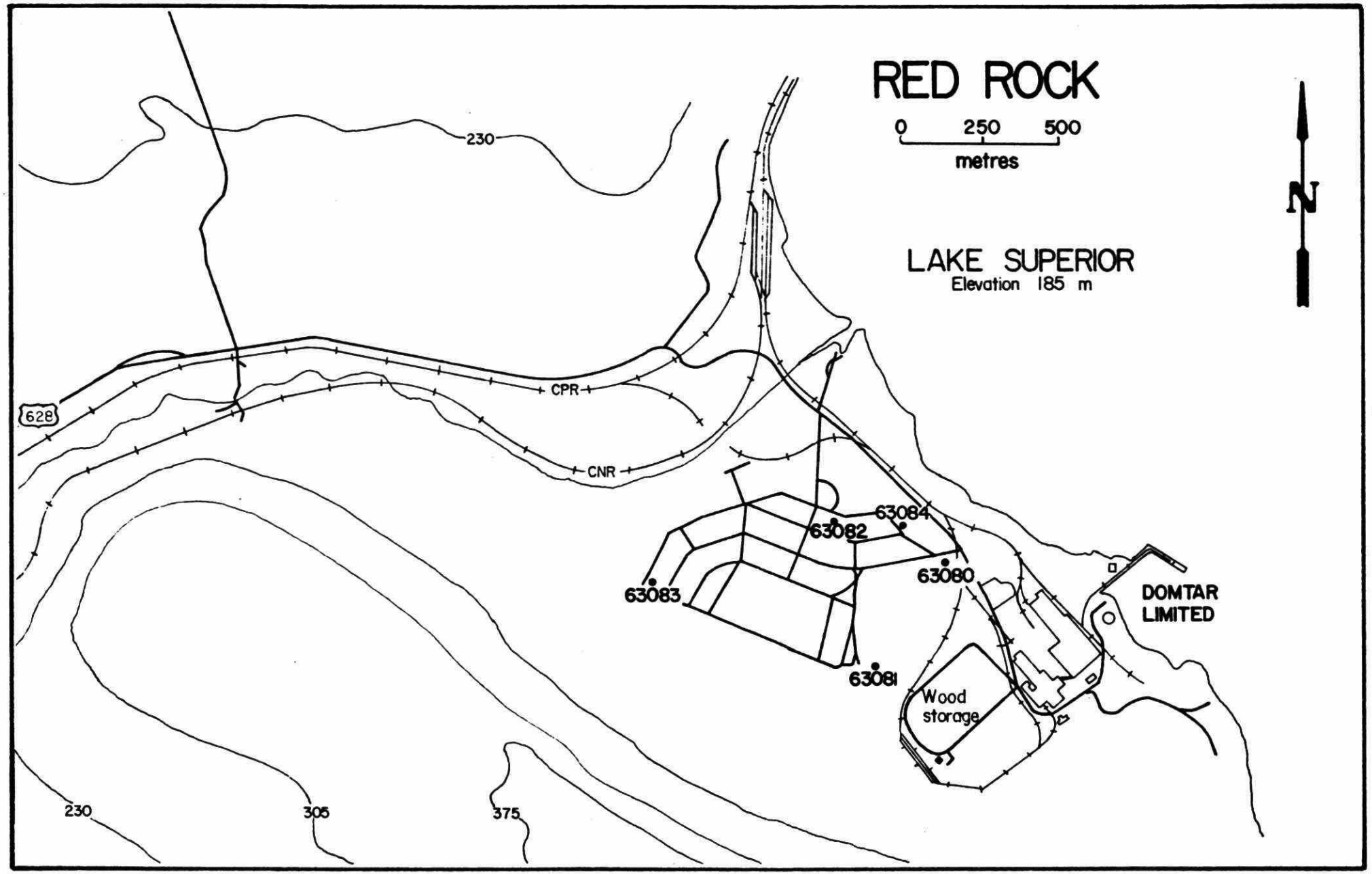

Figure II . Air quality monitoring sites, Red Rock, 1981.

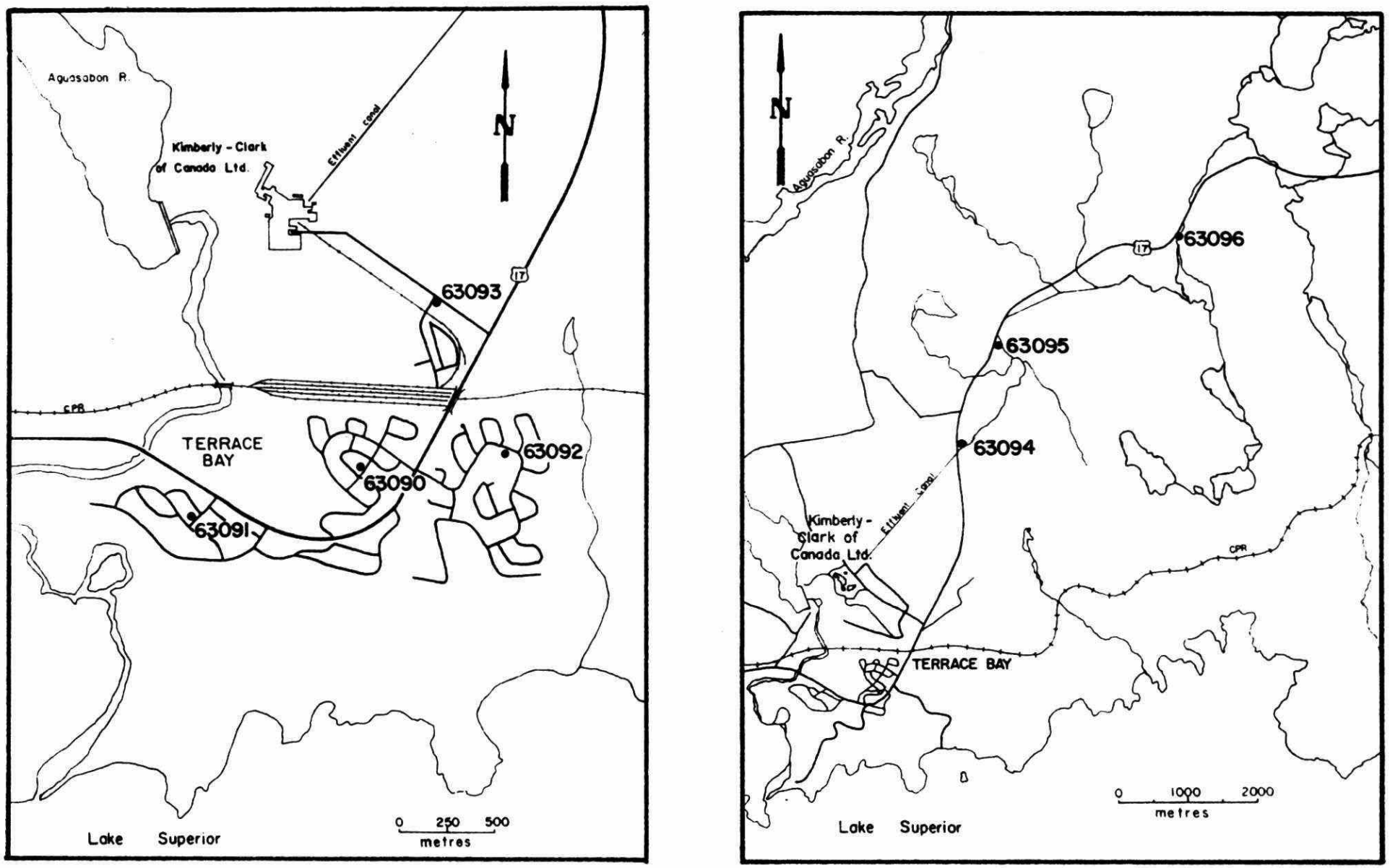

Figure 12. Air quality monitoring sites, Terrace Bay, 1981.

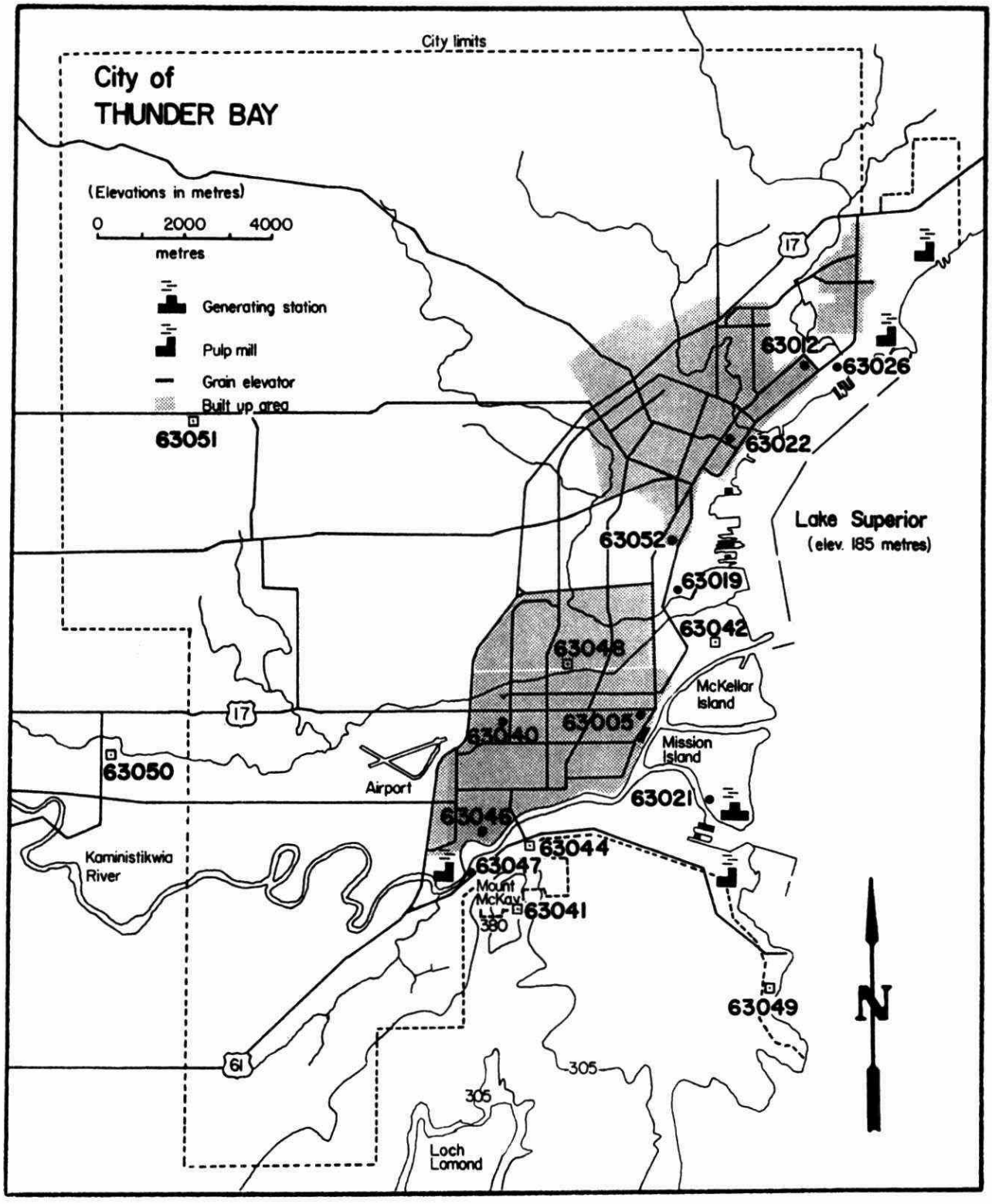

Figure 13. Air quality monitoring sites, Thunder Bay, 1981.
(⊡ Ontario Hydro sites)

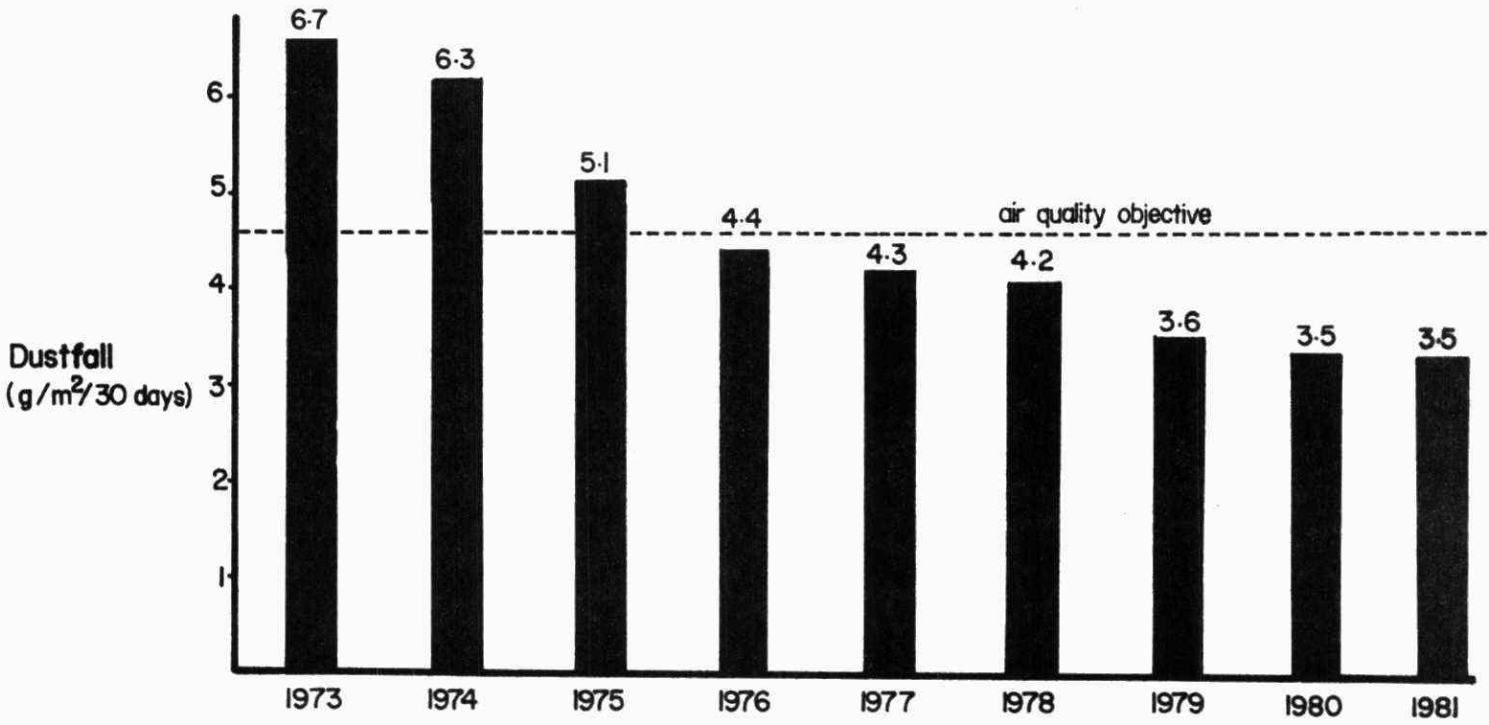

Figure 14. Average annual dustfall, 1973-1981, Thunder Bay.

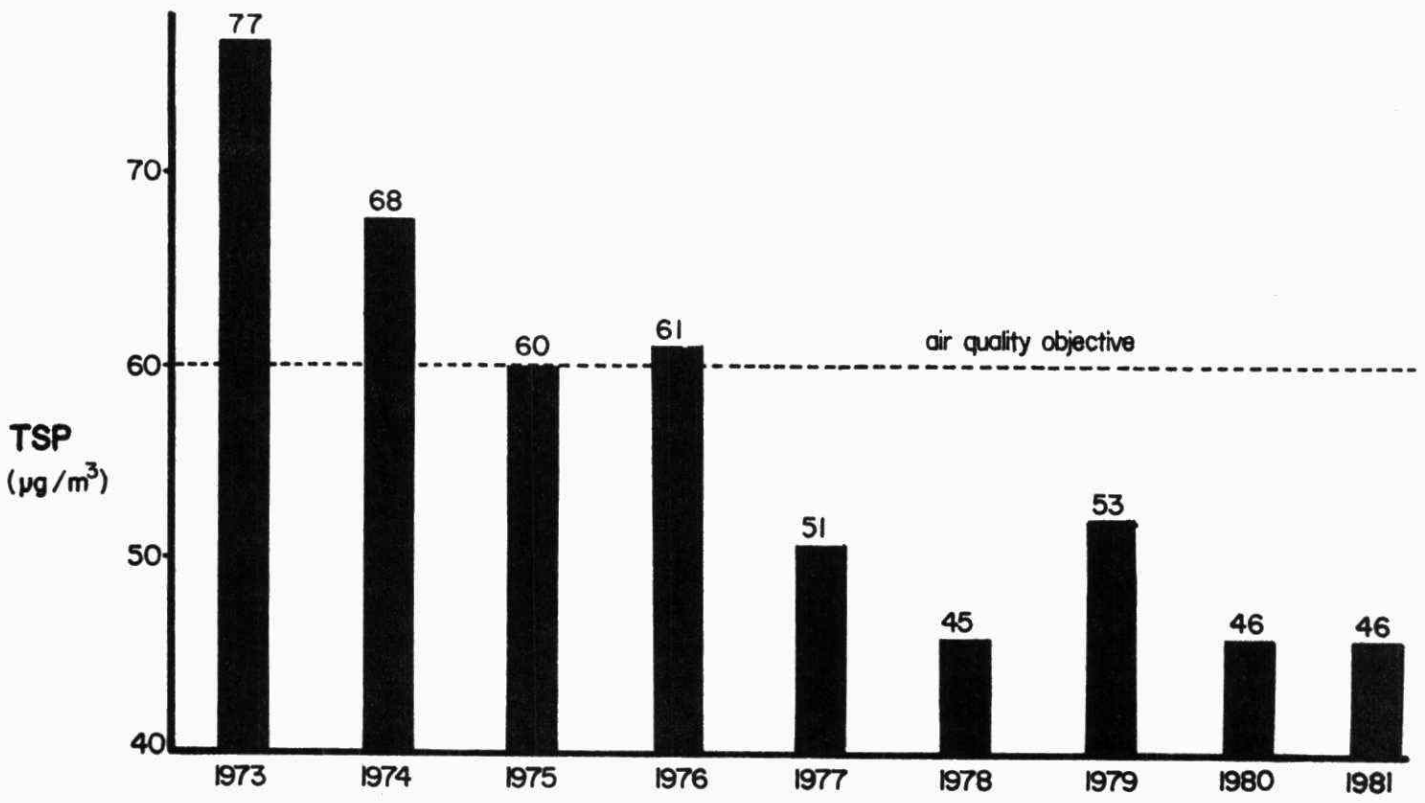

Figure 15. Average total suspended particulate matter (µg/m³), 1973-1981, Thunder Bay.

TABLE 1. Arsenic content (µg/g, dry weight) of unwashed trembling aspen foliage from Balmertown sampled from 1972 to 1981.

Site[a]	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1			26[b]	31	10	5	4	3	6	5
2			22	26	6	12	9	3	6	4
5	160	550	29	33	18	12	9	22	28	6
6	78	400	200	260	50	8	33	11	55	63
7	21	81	43	29	5	4	20	4	4	2
8			14	18	4	2	6	2	2	1
9	260	410	19	6	6	5	5	9	3	5
11	98	110	10	7	2	4	2	5	3	4
12	27	41	9	9	4	3	3	6	12	2
Controls	<1	8	3	2	<1	<1	<1	<1	<1	<1

[a]Shown in Figure 3.

[b]Values above upper limit of normal background concentration (5 µg/g) are underlined.

TABLE 2. Average arsenic content (µg/g, dry weight)[a] of unwashed foliage from planted roadside Manitoba maple and white elm trees, Balmertown, 1973 to 1981.

Year	Side of tree[b]	Dickenson & Mine Road	Balmertown public school	Fifth St. & Mine Road	Controls
1973	Facing	504[c]	734	352	19
	Away	323	432	202	25
1974	Facing	70	36	20	4
	Away	31	21	12	
1975	Facing	138	76	34	4
	Away	58	46	18	
1976	Facing	18	12	20	2
	Away	18	9	11	
1977	Facing	13	6	8	<1
	Away	16	5	8	
1978	Facing	5	5	5	<1
	Away	4	4	3	
1979	Facing	69		8	2
	Away	22		7	
1980	Facing	7	5	6	1
	Away	5	5	3	
1981	Facing	11	7	8	<1
	Away	12	7	5	

[a]Values for 1973, 1974, and 1980 represent single samples. Those for other years are averages of triplicate samples.

[b]Facing and away from gold mines.

[c]Values above upper limit of normal background concentration (5 µg/g) are underlined.

TABLE 3. Average arsenic levels[a] (µg/g, dry weight) in washed vegetation and surface soil (0-5 cm) from three[b] Balmertown gardens, 1973-1981.

Sample	1973	1974	1975	1976	1977	1978	1979	1980	1981
	Balmertown								
Potato (leaves)[c]		18	24	15	9	6	37	17	8
" (tubers)		2	2	2	<1	<1	<1	2	<1
Beet (leaves)	180	8	8	7	7	2	13	8	2
" (roots)	40	3	9	4	6	3	8	6	<1
Lettuce (leaves)	140	9	18	12	7	9	12	36	6
Soil (garden)		160	150	60	360	120	93	160	75
(lawn)		570	450	210	340	280	270	440	320
	Red Lake (control)								
Potato (leaves)		4	2	2	2	1	5	2	<1
(tubers)		<1	<1	<1	<1	<1	<1	<1	<1
Beet (leaves)	3	<1	<1	<1	<1	<1	1	2	<1
(roots)	2	<1	<1	<1	<1	<1	<1	<1	<1
Lettuce (leaves)		2	<1	<1	<1	1	1	2	2
Soil (garden)		10	10	8	7	6	6	7	3
(lawn)		14	10	9	8	11	24	11	7

[a]Values for 1973, 1974, and 1975 represent single samples. Those for other years are averages of triplicate samples.

[b]Two gardens in 1979.

[c]Unwashed.

[d]Values above upper limited of normal background levels (5 µg/g for vegetation, 20 µg/g for soil) are underlined.

TABLE 4. Summary of sulphur dioxide concentrations (ppm) in Balmertown, 1977-1981.

Year	Days of data	Annual average	Maximum		Number of times above objective	
			1-hour	24-hour	1-hour	24-hour
1977	108	0.011	0.56	0.22	31	2
1978	335	0.014	0.75	0.21	133	9
1979	296	0.016	0.70	0.25	153	8
1980	247	0.011	0.70	0.18	76	6
1981	280	0.013	0.93	0.14	83	6

TABLE 5. Average annual dustfall ($g/m^2/30$ days), Dryden, 1976 to 1981.

Year	Station						All stations
	61020	61021	61022	61023	61024	61025	
1976	8.0[a]	6.3	9.8	11.5	5.9	4.5	7.7
1977	5.8	7.7	7.4	8.5	6.0	3.2	6.4
1978	4.7	5.1	6.0	4.6	2.9	2.5	4.3
1979	3.9	4.7	3.2	5.3	2.8	2.7	3.8
1980	3.2	3.8	4.6	5.2	3.8	3.9	4.1
1981	4.0	4.3	4.1	5.6	3.9	4.4	4.4

[a]Values exceeding maximum acceptable limit of 4.6 $g/m^2/30$ days are underlined.

TABLE 6. Average annual sulphation rates (mg $SO_3/100\ cm^2/day$), Dryden, 1976 to 1981.

Station	Location	1976	1977	1978	1979	1980	1981
61021	Casimir/St. Charles		0.16	0.20	0.14	0.16	0.09
61023	King/Wabigoon	0.39	0.34	0.43	0.44	0.35	0.18
61025	Park/Second		0.13	0.12	0.14	0.12	0.10
61026	56 King Street			0.20	0.23	0.18	0.14

TABLE 7. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1977-1981.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1977	325	3.7	164	270
1978	282	6.7	479	400
1979	200	8.7	236	391
1980	275	6.1	436	476
1981	279	5.5	190	405

TABLE 8. Average chloride and sodium concentrations in unwashed Manitoba maple foliage[a], Fort Frances-International Falls, 1979-1981.

Site (Figure 5)	Chloride (%, dry weight)			Sodium (µg/g, dry weight)		
	1979	1980	1981	1979	1980	1981
1	0.93	1.17	0.62	2900	1800	2090
2	0.77	0.81	0.43	1500	1400	2200
3	0.43	0.87	0.40	810	1200	710
4	0.21	0.71	0.22	530	620	330
5	0.25	0.35	0.22	700	260	330
6	0.29	0.36	0.38	680	390	800
8	0.15	0.37	0.22	230	180	140
9	0.21	0.22	0.18	370	150	130
10	0.09	0.23	0.22	270	94	82
11	0.08	0.13	0.14	230	100	80
12	0.12	0.15	0.10	320	150	78
13	0.04	0.04	0.04	290	83	72
14	0.15	0.08	0.08	140	53	126
15	0.22	0.36	0.33	310	120	160
16	0.14	0.53	0.16	260	73	69
17	0.07	0.08	0.12	390	65	67
18	0.13	0.21	0.11	240	120	60
20	0.10	0.10	0.09	240	250	140
21	0.24	0.15	0.11	400	250	70
22	0.13	0.13	0.12	330	240	100
23	0.16	0.26	0.12	140	280	100
24	0.13	0.42	0.24	180	210	150
25	0.15	0.17	0.20	280	410	230
Controls	0.06	0.10	0.08	46	100	56

[a]Values are averages for one set of triplicate samples in 1979, and one set of single samples in 1980 and 1981.

[b]Values above upper limit of normal background concentration (600 µg/g) for sodium in vegetation are underlined.

TABLE 9. Average annual dustfall (g/m²/30 days), Fort Frances, 1979-1981.

Station[a]	1979			1980			1981		
	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake
62030	8.5[b]	4.2	1.6	7.1	4.0	1.2	7.9	4.9	1.3
62032	4.2	2.1	0.9	3.0	1.7	0.4	3.4	2.2	0.2
62033	12.2	3.7	4.8	8.2	3.5	2.5	9.7	4.0	2.9
62034	8.0	3.6	1.5	5.2	3.2	0.8	8.0	5.2	0.7
62036	11.7	6.6	2.3	10.6	6.6	1.4	10.0	6.2	1.3
62037	5.4	2.1	1.1	5.5	2.2	0.6	4.3	2.6	0.4
62046	10.6	6.1	2.0	9.7	6.0	1.6	10.4	6.2	1.5
Averages	8.6	4.0	2.1	7.0	3.9	1.2	7.7	4.5	1.2
% of total dustfall		46	24		56	17		58	16

[a]See Figure 6 for station locations.

[b]Values exceeding annual objective of 4.6 g/m²/30 days are underlined.

TABLE 10. Average annual sulphation rates (mg SO_3/100 cm^2/day), Fort Frances, 1979-1981.

Station	Location	1979	1980	1981
62030	Church/Portage	0.20	0.14	0.11
62032	Cemetery	0.13	0.09	0.05
62033	Nelson/Portage	0.40	0.27	0.24
62034	First/Victoria	0.13	0.09	0.05
62036	Sinclair/Victoria	0.13	0.09	0.06
62037	Reid/Gillon	0.09	0.09	0.05
62046	Sinclair/Portage	0.23	0.12	0.11
	Averages	0.19	0.13	0.10

TABLE 11. Summary of total reduced sulphur concentrations (ppb), stations 62030 and 62032, Fort Frances, 1976-1981.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 62030		
1976	309	12.8	458	916
1977	294	15.4	480	969
1978	304	16.1	540	1035
1979	344	10.2	353	911
1980	352	9.3	499	872
1981	277	12.0	279	806
		Station 62032		
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202

TABLE 12. Average hourly concentrations (ppb) of total reduced sulphur for different wind directions, Fort Frances, 1978-1981.

Wind direction[a]	Station 62030				Station 62032			
	1978	1979	1980	1981	1978	1979	1980	1981
350-20	1	1	2	<1	2	3	3	2
30-60	<1	<1	<1	<1	<1	2	2	1
70-100	<1	<1	<1	<1	2	3	3	3
110-140	2	1	1	1	9	9	9	9
150-180	27	17	15	13	6	8	10	8
190-220	74	51	47	58	<1	<1	1	<1
230-260	26	17	18	13	<1	<1	<1	<1
270-300	4	2	2	2	<1	<1	<1	<1
310-340	3	3	2	3	<1	<1	<1	<1
Calm	17	16	13	20	4	3	5	7

[a]Degrees, 6.4 m above ground, International Falls airport, Minnesota.

TABLE 13. Average annual dustfall ($g/m^2/30$ days), Kenora, 1977-1981.

Station	Location	1977	1978	1979	1980	1981
61003	Fourth/Main	5.7	9.5	4.6	4.1	4.7
61007	Melick/Ninth	11.9	14.7	8.6	10.7	14.1
61008	Melick/Eleventh	3.7	5.3	3.8	3.7	4.1
61009	Third/Matheson				5.6	7.1

[a]Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 14. Average annual sulphation rates (mg $SO_3/100\ cm^2/day$), Marathon, 1976 to 1981.

Station[a]	1976	1977	1978	1979	1980	1981
63027	0.22	0.27	0.37	0.15	0.12	0.10
63029	0.15	0.17	0.20	0.17	0.09	0.09
63030	0.18	0.23	0.23	0.15	0.11	0.11
63031	0.46	0.56	0.71	0.19	0.20	0.09
63032			0.10	0.10	0.06	0.07
63033				0.16	0.16	0.15

[a]See Figure 10 for station locations.

TABLE 15. Average annual dustfall (g/m²/30 days), Red Rock, 1979-1981.

Station[a]	1979			1980			1981		
	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake
63080	5.2	1.6	2.2	9.2	4.0	2.6	8.6	3.3	2.7
63081	5.8	3.0	1.2	7.4	3.4	1.8	5.3	2.4	1.4
63082	7.2	2.0	2.9	12.5	3.6	6.0	14.7	3.2	8.4
63083	4.0	1.7	1.1	3.8	1.5	1.2	3.1	1.3	0.8
Averages	5.6	2.1	1.8	8.2	3.1	2.9	7.9	2.6	3.3
% of total dustfall		38	33		38	35		33	42

[a]See Figure 11 for station locations.

[b]Values exceeding annual objective of 4.6 g/m²/30 days are underlined.

TABLE 16. Average annual sulphation rates (mg SO_3/100 cm^2/day), Red Rock, 1979-1981.

Station	Location	1979	1980	1981
63080	Rankin Street	0.58	0.66	0.46
63081	Stewart/Frost	0.13	0.15	0.15
63082	47 Timmins Street	0.24	0.27	0.27
63083	122 Brompton Road	0.09	0.13	0.11
	Averages	0.26	0.30	0.25

TABLE 17. Total dustfall (g/m^2/30 days) and average pH of dustfall solutions, Thunder Bay, 1981.

Station	Location	Dustfall			pH[a]
		Min	Max	Mean	
63005	McKellar Hospital	1.3	9.2[b]	3.7	4.1
63012	Dawson Court	0.8	9.2	3.5	4.3
63019	Main St. Pumping Station	0.5	15.3	3.5	4.1
63021	Mission Island	0.8	4.4	2.1	3.8
63022	St. Joseph's Hospital	0.8	9.9	3.9	4.0
63026	N. Cumberland Hydro	0.8	9.6	4.1	4.2
63040	435 James St. South	0.6	8.3	2.9	4.1
63046	Montreal Street	4.2	9.9	7.0	7.0
63047	Totem Trailer Court	1.8	12.7	7.8	6.5
63052	Thunder Bay Transit	0.5	10.1	4.2	4.1

[a]No data for January, July and August.

[b]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 18. Total suspended particulate matter (µg/m³), Thunder Bay, 1981.

Station	Number of samples	Annual geometric mean	Number of samples above 120 µg/m³	Maximum 24-hour value
63005	60	52	3	178[a]
63012	60	39	5	170
63022	59	44	4	156
63040	55	37	nil	117
63046	58	61[a]	10	174
63052	56	51	8	238

[a]Values exceeding the maximum acceptable limit of 120 µg/m³ (24-hour average) or 60 µg/m³ (annual geometric mean) are underlined.

TABLE 19. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1981[a].

Station	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.04	0.01
63040	435 S. James Street	0.001	0.23	0.02
63041	Mt. McKay		0.22	0.04
63042	East End		0.17	0.03
63044	James St./Kam River		0.16	0.03
63048	Ford Street		0.16	0.02
63049	Chippewa Park		0.16	0.04
63050	Paipoonge		0.07	0.01
63051	John Street Landfill		0.05	<0.01

[a]12 months of data for station 63042, 11 months for 63048 and 63049, 10 months for 63044 and 63050, and 6 months for 63041 and 63051.

TABLE 20. Summary of total reduced sulphur concentrations (ppb), station 63046, Thunder Bay, 1977-1981.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1977	298	1.5	56	17
1978	280	1.9	48	28
1979	218	2.6	58	26
1980	220	2.9	131	90
1981	340	2.8	72	74